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JUNE 1960

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A Journal for All Science and Mathematics Teachers

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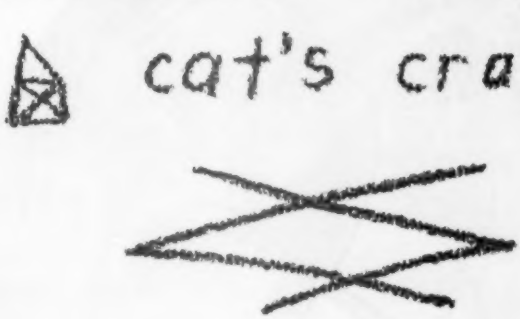

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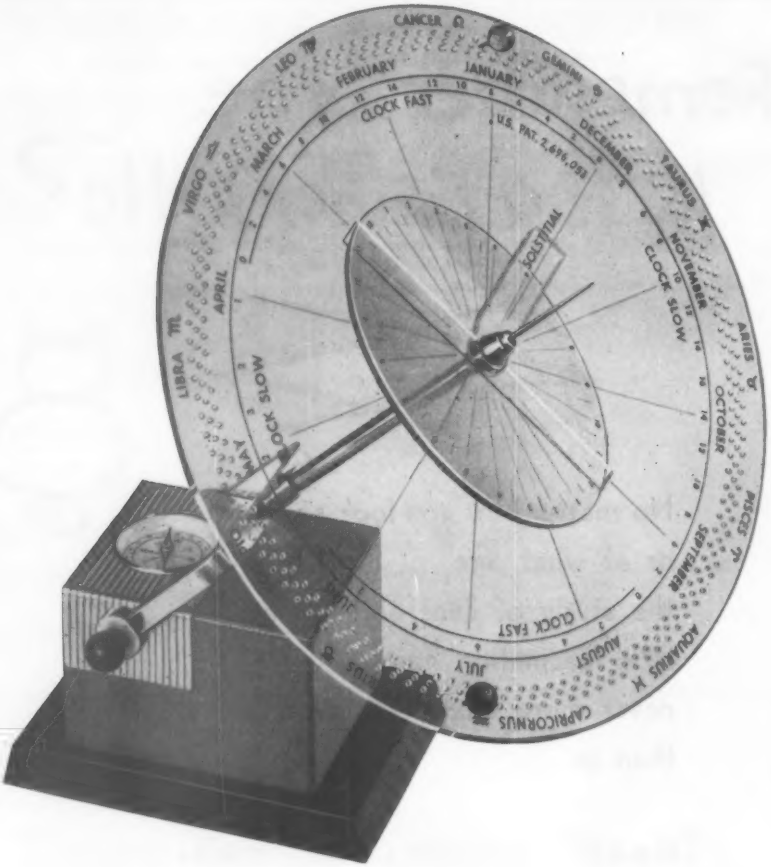

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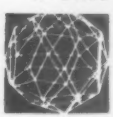

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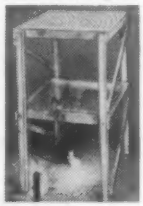

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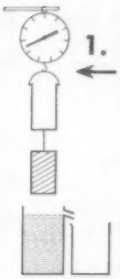

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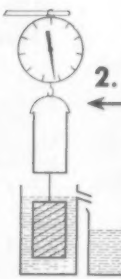

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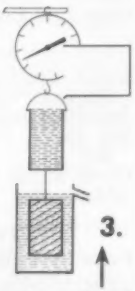

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A Look at Creativity

Roy H. Cook

School of Engineering, Pratt Institute, Brooklyn 5, N. Y.

Creativity has become a familiar term today. At any rate, its sound has become familiar even though its meaning varies widely from person to person. Almost everyone is certain, in any case, that problems arise faster than we can solve them, and that creativity, therefore, must be in short supply. Perhaps this is a transient condition that exists because humanity does not and indeed cannot react instantly to its own need. Other possibilities are that our educational procedures fail to develop creativity or that they actually stifle it. Educational inadequacies usually can be eliminated and many believe that this is a situation which demands urgent and perhaps even radical measures. Few are inclined to consider our condition as transient. As a consequence "experts" of all kinds are urging, even pressuring educators to design new curriculums, to introduce new techniques and to shift emphasis to novel and exotic areas. Although changes in curriculums, techniques, and emphasis may be necessary, it is highly improbable that improvement will result from wholesale modifications based purely upon speculation. Without question, experimentation is both desirable and necessary. It must be carefully planned and properly controlled if one is to relate cause and effect and distinguish between good and bad results. Experimentation should be our first step. Wholesale changes may or may not be indicated as the second step.

In any case, it is worthwhile to develop a concept of creativity as a starting point for discussion and perhaps for planned investigation.

The development which follows is based upon ideas that arose in conversations with scientists, engineers, mathematicians, artists, writers, architects, industrial designers and psychologists. It does not represent completely the opinions of any one such group, nor is it entirely objective. Since its purpose is to instigate action toward the definitizing of a concept, however, neither of these points is particularly important.

1.1 *Thinking and Reasoning*—As an aid in the discussion of creativity, it is desirable to set down certain terminology and ideas regarding the mind and its action.

Information is stored in the mind in many forms. For example, words with or without the concepts which they represent are pieces of information held by the mind. Conversely, concepts without words to represent them can also be stored. For any particular mind there appears to be a limit for the complexity of concepts which can be stored and recalled. Extremely complex concepts can be built, however, by the combining of simple ones. For example, the concepts cat, C, rattlesnake, R, and bite, B, can be combined in several ways as: CBR, the cat bites the rattlesnake; RBC, the rattlesnake bites the cat; RBR, the rattlesnake bites himself and so on.

Operational schemes such as mathematics and logic are also stored and it is possible to use or ignore such schemes in the process of building complex concepts from simple ones. Theories and opinions can be applied or ignored as simple concepts are combined.

There are two extremes of mental activity. In one, simple concepts are combined with little or no regard for theories, opinions or operational schemes. This frequently happens in dreaming. We shall call this process, thinking. At the other extreme, concepts are combined with strict reliance upon theories and operational schemes. We shall refer to this process as reasoning. Most mental activity is a mixture of these two.

1.2 *The Creative Action*—Although most persons use the word, creative, loosely, they maintain that creativity is identified easily. Something vaguely known as a creative action is basic to their method of identification. There is general agreement that such an action must involve some original element. That is, some part of a creative action is not a copy or imitation. Originality, as it relates to such matters, is personal, however, since one could not copy something of which he was ignorant.

Some of those consulted felt that one should restrict the term, creative action, to accomplishments of the mind: that is, they considered a poem or painting to be the result of one or several creative actions. The execution, in itself, was not viewed as creative but as

a combination of experimentation, to aid the mind, and representation of the final concept. Physical ability or skill of an artist was regarded in the same light as the ability or skill of a weight-lifter. We shall adopt this restriction. Should an action be called creative if it does not arise from a deliberate intent to create? Lamb's Chinese could hardly have been credited with creating roast pig. Had he recognized the cause and effect relationship implied by his experience and deliberately devised a practicable method of roasting pig, then he could have been called creative. The question of deliberate intent clearly is concerned with the exclusion of purely accidental actions which might otherwise be called creative. It is entirely reasonable to exclude accidents, but in doing so, one must be very careful not to exclude deliberate creative actions which were triggered or instigated by an accident.

Thus, we are led to three criteria for the identification of a creative action. They are: (1) the action must, in some respect, be original; (2) it must be an accomplishment of the mind; (3) it must arise from a deliberate intent to create.

1.3 *Creativeness*—The word creativeness has to do with the capability for achieving creative actions. It is used indiscriminately with regard to individuals and groups. One frequently hears remarks such as: John has greater creativeness than Joe, or action A, required greater creativeness than action, B. Thus, there is the belief that creativeness can be evaluated or at least ordered, although procedures for evaluating or ordering are not well established. A somewhat standard technique is that of confronting a collection of individuals or groups with situations which call for creative actions, and counting the actions which come from each individual or group. Greater creativeness is said to be associated with larger counts. This method patently ignores differences between the qualities of the actions themselves.

The word, creativity, is ordinarily taken to have the same meaning as creativeness.

2.1 *Creativeness and Problem Solving*—A problem here is a situation involving imperfection along with a demand for the removal or reduction of this imperfection. Solution of the problem is the removal or reduction of the imperfection. For example, polio in recent years and the absence of a method for combating its spread, constituted a problem; Salk's development of a vaccine was a solution. An amplifier which gives undesirable emphasis to a band of frequencies forms a problem; elimination or reduction of the emphasis is a solution.

For each of us, life involves a succession of problems most of which

we solve without difficulty. Frequently, both mental effort and deliberate intent are involved, but originality is not often necessary. In other words, a large fraction of our problems do not involve creative action. Most of the population gets by very well by copying or imitating, or simply by ignoring imperfections. Creative action, however, is the essential element of some occupations. This is particularly true of literature, the arts, science and engineering.

It is important to examine the problem solving process in an effort to discover the nature of creative action.

Thinking and reasoning were defined in Section 1.1, and the storage of concepts was discussed. Presumably, concept storage results from unorganized experience, and education, both formal and informal. The mind interacts with the physical and chemical body in which it resides and indirectly with the external world. Concepts are the interpretations of these interactions. If the human organism is confronted by a somewhat complex problem, the mind quickly searches through its simple concepts, its more familiar combinations of ideas, its theories and opinions, in an effort to find a solution or a promising method of attack. It may think or reason or do both. Whether the mind succeeds or not depends upon many things, most of which are known only with great uncertainty. If, however, those concepts, theories, operational schemes and so forth, which are stored cannot, in any combination, constitute a solution, then failure is certain. The mind may recognize its deficiency of knowledge, however, devise and execute ways of securing necessary information and ultimately effect a solution. If a small boy is asked to state the position and velocity of a thrown ball as a function of time, he is unequal to the problem. He has vague concepts of weight, motion, position and time, but he is unaware that they are related. A more experienced person, with a knowledge of calculus, might be unaware of the relationships, but knows that they existed. It is practicable for this person to secure the necessary knowledge and produce an acceptable solution.

The important point is that if no possible combination of stored concepts can constitute a solution, the failure is certain. By implication, then, an extensive background of experience and education should be conducive to problem solving success. But many other factors are involved. Some of these are concerned with the mind and some with problem specification. Important among the former are: fear of making a mistake; inability to stand criticism; negative opinions; and excessive worry regarding rigor. As to the latter, problem specification, three situations present themselves. They are loose specification, tight specification and over-specification. A loosely specified problem will have many solutions, any one of which is

acceptable. A problem which is tightly specified will have few solutions, possibly only one. An over-specified problem will have no solution. Clearly, the probability of building a solution from the concepts of a given mind depends upon problem specification.

The solving of a particular problem may or may not require creative action. By and large, this means that an original solution may or may not be required. In any case, unless every possible solution of a particular problem is original, the demand that solution arise through creative action has the same effect as the tightening of specifications. It reduces the number of possible solutions and hence the probability of success diminishes.

Evidently, the effort exerted to produce a creative action is not basically different from that employed in the solving of problems in general. This is a significant point. If it is true, then the same procedures which produce good problem solvers should lead to the development of creativity.

3.1 *Education for Creativity*—A picture of creativity has been presented in the earlier sections. It was stated there that the effort to be creative was not different from that required to solve problems in general. We shall be interested, therefore, in those educational procedures and goals which lead to effective problem solving.

Since intuition and experience, clearly understood theories, and powerful operational schemes are important we must educate with these as objectives. Presently, in Science and Mathematics we devote much time and energy to operational schemes. Intuition, however, is seriously slighted. Only by accident does the student develop an intuitive feeling for his field. He is urged and aided to become skillful in specific manipulations which apply to precisely designated circumstances. He is trained to reason but unfortunately given few opportunities to just think. Indeed, imaginative possibilities that arise from just thinking are often prohibited and sometimes violently squelched. In other words, there is a tendency among educators to frown on the intuitive approach and to steer students into the purely mechanical, carefully reasoned attack. Ultimately students reach the conclusion that intuitive processes are improper.

Experience, the mother of intuition, is difficult to achieve at the undergraduate level because the student is, for convenience, forced into a passive role. In this role he has many specific tasks to accomplish, a multitude of skills to master. He must "verify physical laws," or so it is said, with ready made equipment manipulated by cookbook procedures. To be sure, this is an experience but one which is superficial and deadening. The same passive, superficial, and unchallenging role is expected of the student even in such courses as mathematics.

It would seem that less rigid regimentation, both physical and intellectual, would be desirable. There should be deliberate stimulation of the imagination and greater willingness to examine its produce. Thinking should be aided and abetted as a proper prelude to reasoning. Laboratories should provide experience in the solving of problems by student designed procedures. In fact, the design of a procedure should involve intuition, reasoning, and perhaps even auxiliary experimentation. It is in such ways that experience and intutition are developed.

In Section 2.1, mention was made of attitude and its importance to problem solving. Attitude and the entire matter of personality receive only accidental attention in most engineering curriculums. And yet, the development of self-confidence and a positive attitude is immensely important to the problem solver, particularly if he must display his wares to his colleagues and supervisor for evaluation and criticism. The whole area of personality, especially that part related to inhibitions, needs serious study directed toward the discovery of effective educational procedures.

Creative action calls for free-wheeling thought. If each budding idea is subjected to comparison with established rules, or methods, or studies for rigor, then the thinking process will be slowed to a walk. There is something substantial behind the notion that creative people are dreamers. In dreams, one's mind is not impeded by opinions, ethics, standard practice, or any rule. Consequently, in dreams, one visualizes magnificent combinations of concepts as his mind goes thinking along its merry way. Thinking which is unfettered by rules, methods, rigor or even reason, is the kind which produces the new idea, the creative action. Again attitude is involved, along with the habit of thinking. Proper attitudes and habits of thinking cannot be developed as afterthoughts. They must be encouraged throughout education, and if they are not, then creativity may be effectively stifled. Nowhere is this more obvious than among the graduates of certain mathematics programs. These young people are so trussed up with rigor and fundamental postulates, that the thought of actually doing something on their own, terrifies them.

Most persons experience no strong desire to be creative. In fact, a ridiculously small percentage of the population is responsible for all creative output of significance to society. Education has a very definite responsibility to inspire its product with the desire to go beyond the known, to be creative. It should make the student aware of the excitement of original accomplishment. That student who has the opportunity to see inquisitive scholarship in action and to have a part in its work seldom fails to be inspired with enthusiasm.

Education for creativity must not be viewed as a course to be

given in the senior year. It must be spread throughout the curriculum; perhaps lightly at first, but rapidly increasing in intensity and comprehensiveness. Conceivably, it might even invade the sacred privacy of established courses.

Broadening One's Teaching Base

Stanley B. Muliak

University of Utah, Salt Lake City, Utah

Some high school principals want their teachers to teach subjects other than their majors in order to broaden them. Even if there is one such principal, that's too many. The following is an example of the broadening experience received by an individual who was neither a general science nor a biology major but who taught a lesson on "vertabrates" (sic) in a general science class. I had the ill fortune to listen to him for half an hour. I was sorry for him, realizing that he was caught in an "administrative device" and was teaching a subject I felt he suspected he knew little about. Further, I believe he knew I knew his weakness. Worse yet, he no doubt felt that some of his students knew it also. The material presented as statements were as near direct quotations as was possible.

It is hard to understand how administrators can condone such practice. Most of them who are steeped in education lore hardly know enough about the "meat" in their school curricula that they don't sense— they can't know—the harm done through inadequately prepared teachers. I mean inadequately prepared in the subject matter they teach, not in professional education.

Title of unit. Vertebrates. (On bulletin board-Vertabrates) (sic)
Assignment: Bring items for bulletin board.
The following are excerpts taken from the discussion.

(Instr.) Today we will continue studying of animals. What are animals made of?

(Student answers) Cells.

(Instr.) Yes, that's right, cells. Cells are found in plants and animals. How do plant and animal cells differ? (There is more discussion here by the instructor before student answers and instructor continues. Yes. That is right. Animal cells are made of cytoplasm and plant cells are made of protoplasm. Cytoplasm is a sort of a protoplasm.

(Question by instr.) How are animals broken down?

(Student) Into genus and species.

(Instr.) That is right—into genus and species.

There is some more discussion I didn't follow. Then . . .

(Instr.) Plants are broken into phyla and class. The phyla in plants is the same as the genus in animals, and the class is the same as species.

(Instr.) How are animals named?

(Student) Latin

(Instr.) Yes. It is a universal language, so a Frenchman would know that *Musca domestica* is a housefly as we do . . . (Instr. comments about how this is a good system and raises a few more ideas, several "new" to me.)

(Instr. continues.) Now a horse and a dog are in the same genus, but they are different species. (This is new to me also.)

(There follows some general discussion about some structures in both of these animals—some ideas I don't grasp.)

(Instr. continues) A bat and a grasshopper both fly; so they are the same

genus, but different species . . . (I became disturbed and didn't hear clearly what was said for a while).

(Instr.) Now let's take anteaters. Why are there no anteaters here?

(Mary) Because there are not enough ants here.

(Instr.) That's right, because there are not enough ants here.

(John interjects.) There are no anteaters in Alaska either.

(There is more discussion about anteaters. I have trouble following all of the "new" concepts presented.)

Jane raises a hand.

(Instr.) What is it Jane?

(Jane) Does an anteater kill the ant when it gets on its tongue?

(Instr.) No. Because the sticky stuff on the anteater's tongue isn't poisonous.

(Instr.) What is the place called where we find anteaters? (He answers his own question) A community. We find them there because it is a community.

(He expands a bit on what a community is.)

(Instr. continues) Now let's take a frog. I watched a frog last summer creep toward a butterfly. When it was about a foot or foot and a half away it jumped and sticks its tongue out. Now Mary, how does the tongue catch the insect?

(Mary) By curling its tongue this way. (Demonstrates with her hand.)

(Instr.) Now let's take another kind of feeding. (A short discussion here about cougars, then quote) When a cougar eats a rabbit . . .

(Student raises hand)

(Instr.) Yes. What is it?

(Student) Would he eat a sick rabbit?

(Instr.) Yes. Oh yes, but if a cougar ate a rabbit with a disease, it would get it, and if you ate the cougar—of course we don't eat cougars—but if we ate the cougar without cooking it you would get the disease.

Some more discussion follows here, though I don't follow all.

(Instr. continues) What is a parasite? We talked about parasites yesterday. Mary?

(Mary answers)

(Instr. repeats and continues) That's right, a parasite is one which lives at the expense of another. What do we call that other?

(Student answers) A host.

(Instr.) That is right—a host. (Children all laugh. I did not know why. Must have been a situation about hosts yesterday.)

(Instr.) Now let's take another. If a dog is killed, why saprophytes eat it. Saprophytes are like bacteria and little animals.

(Student raises a hand)

(Instr.) What is it?

(Student) I saw maggots get into dead matter. (Some of the class shudder?)

(Instr.) Yes, John, we could call them saprophytes.

(Henry volunteers) What are vultures then?

(Instr.) They are something different. Now let's take something else. (Evasion) Meat has little cysts in it sometimes. What are they called?

(Student answers and instructor repeats.) Why, tapeworms, of course.

There is a little more of some kind of discussion and then the instructor has every one read for next day's lesson.

Please don't ask me to expose this teacher, undoubtedly a good person, caught in an administrative device. This is undoubtedly an extreme case, but knowledge of the scant background of the average non-science major teaching a science class indicates that lessons like the above must be commonplace.

Recent Revisions in Soviet Mathematics Education

Bruce R. Vogeli

Bowling Green State University, Bowling Green, Ohio

In recent months, Soviet school programs in all subject matter areas have been revised extensively. Reforms enacted were initiated in response to proposals put forth in the fall of 1958 by Nikita Khrushchev. Khrushchev's proposals were the culmination of a series of gradual changes designed to render Soviet school programs more practical—more closely connected to life.[1]

Prior to Khrushchev's pronouncements, the Soviet school of general education consisted of ten grades or classes. Pupils entered the first grade at age 7 and, if successful, graduated from grade X at age 17. The ten-year school, as it was called, was academically oriented. This was especially true of grades VIII, IX, and X. Pupils desiring practical or vocational forms of secondary education left the ten-year school after grade VII. Various special professional schools absorbed those drop-outs who wished additional formal education. Others entered industry or agriculture directly.

Traditionally, pupils completing the entire ten-year program were destined for higher education. The training they received in the ten-year school was good for little else. In the years since the war, increasing numbers of ten-year school graduates have failed to gain admission to Soviet institutions of higher learning. Their lack of professional or vocational training (and perhaps more important, their distaste for manual labor) made these graduates as a group unsuitable for many forms of employment. Some refused to accept jobs at all. Others did so only grudgingly. These facts, when coupled with existing manpower shortages in Soviet industry and agriculture, supply the motive for Khrushchev's action.

The academically oriented ten-year school is being replaced by a compulsory eight-year program. Instruction in the eight-year program will emphasize the polytechnic as well as the academic. The eight-year school will be followed by three years of *non-compulsory* schooling *combined* with work experience.[2] Pupils will enter the eight-year school at age 7. The matriculation age for three-year schools will vary with the individual and with the type of school. In no case will it be less than 15. Only persons who have completed both the eight-year school and the three-year program successfully will be permitted to apply for admission to institutions of higher learning. Priority of

[1] "Novyi etap v razvitii sovetskoi shkoly," *Matematika v shkole*, Number 6, November–December, 1958, pp. 1–3.

[2] *Pravda*, December 25, 1958.

admission to higher institutions will be given persons with a record of actual professional employment.[3]

The change-over from the ten-year organization to the eight-three organization is to be accomplished within the next five years. Already many ten-year schools have been reorganized. Transitional syllabi and academic schedules or "plans" which distribute the work of the ten-year school over an eleven-year period have been prepared and published.[4] These documents should be considered temporary. The eleven-year school, as originally conceived, differs from the ten-year school in approach and content as well as organization. The mere redistribution of ten-year topics cannot achieve completely the aims set for the eleven-year school.

Work already has been begun on the development of syllabi and materials for use in eleven-year schools of the future. There are indications that the position of mathematics within the total program will change significantly. Every pupil completing the ten-year school studied arithmetic, elementary and advanced algebra, plane and solid geometry, and trigonometry.[5] A parallel organization was employed throughout grades VI to X, i.e., pupils studied two or more mathematical disciplines simultaneously. In grade IX, for example, pupils studied algebra two hours each week, geometry two hours, and trigonometry two hours. Table I illustrates this organization clearly. In all, pupils devoted 1980 hours to the study of mathematics in the course of the ten-year period. This total represents approximately 20% of all hours spent in the study of all school subjects. The hours allocated individual mathematical disciplines are summarized in Table II.

Students enrolled in the new compulsory eight-year program will study only arithmetic, elementary algebra, plane geometry, and the rudiments of metric solid geometry and trigonometry.[6] In all, 1615 hours or about 22% of all school hours will be devoted to the study of mathematics.[7]

Pupils completing the eight-year school may choose to enter industry or agriculture, to continue their education by attending full-time three-year schools offering instruction in both academic and polytechnic subjects, or to combine labor and learning by attending part-time evening or seasonal schools of general education. Pupils enrolled in full-time polytechnic schools will devote four hours each week to mathematics. Part-time pupils will study mathematics for only three hours each week.[8]

[3] *Ibid.*
[4] *Matematika v shkole*, Number 5, September–October, 1959, pp. 55–56. *Infra.*, Tables I and VI.
[5] *Programmy srednei shkoly na 1959–60 uchebnyi god. Matematika.* Moscow: Uchpedgiz, 1959.
[6] "Proekt programmy po matematike," *Matematika v shkole*, Number 4, July–August, 1959, pp. 1–14.
[7] *Uchitel'skaia gazeta*, Saturday, August 29, 1959, p. 1.
[8] *Ibid.*

Pupils completing both the eight-year school and the full-time three-year program will spend a maximum of 2067 hours in the study of mathematics. This represents approximately 18% of all hours in all subjects.[9] Graduates of the eight-year school and the part-time three-year school will receive 2020 hours of instruction in mathematics.[10]

It should be emphasized that the three-year program is *not* compulsory. Hence, it probably will be completed by only a minority of pupils. On the other hand, even the ten-year school was highly selective, enrolling at most one-third of the appropriate age group in the last three grades. If it is assumed that the new three-year program will attract a comparable portion of the school-age population, it would appear that timewise, at least, the status of mathematics will be enhanced by the reorganization.

Subjectwise, the picture is not yet clear. Final judgment must await publication of materials and texts designed for use in eleven-year schools. Experimental or "project" syllabi in mathematics for grades V–VIII of the eight-year school and for all types of three-year schools have appeared. Table III lists the major topics to be studied in grades V–VIII of the eight-year school. The major topics of one three-year program are itemized in Table IV. It may be informative to compare these syllabi with the current ten-year school syllabus summarized in Table V. The transitional syllabus (Table VI) is given for reference only. It will not be examined in detail here.

Several changes are discernible in the arithmetic program. In an effort to "relate instruction in arithmetic more closely to the requirements of practice," the number of hours allotted the topic "Decimal Fractions" has been increased at the expense of the topic "Common Fractions." Formerly, decimal fractions were allotted fifty hours; common fractions, ninety hours. In the project syllabus, decimal fractions receive seventy-two hours; common fractions, sixty-six. In addition, a section concerning practical applications of both common and decimal fractions has been added to the fifth grade program.

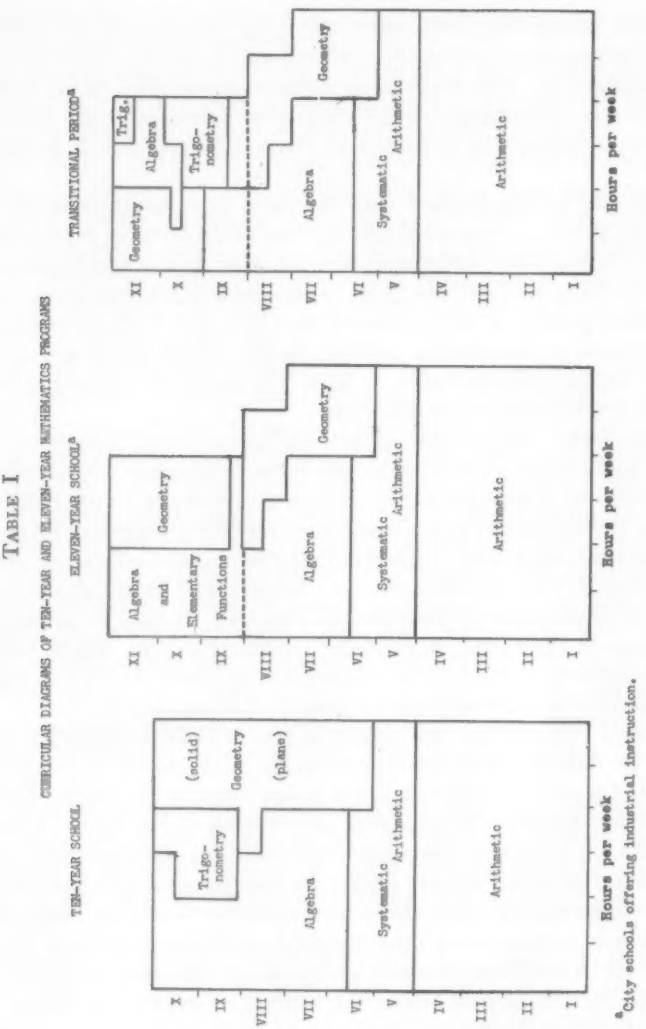
With the aim of simplifying the arithmetic course, the major topic "Divisibility of Numbers" has been omitted in the project syllabus. Theoretical portions of this topic have been dropped altogether, e.g., divisibility of the sum or difference of two numbers by a third. The more useful ideas, e.g., tests for divisibility by 2, 3, 5, and 6, have been subsumed under the major topic "Whole Numbers." Others are now found under "Applications of Common and Decimal Fractions; Practical Work", e.g., arithmetic mean.

According to explanatory sections of the project syllabus, questions

[9] *Ibid.*
[10] *Ibid.*

TABLE I

CURRICULAR DIAGRAMS OF TEN-YEAR AND ELEVEN-YEAR MATHEMATICS PROGRAMS



of approximate computation must be considered if the arithmetic course is to be truly practical.[11] Hence, a major topic "Approximate Computation" has been added to the program at the sixth grade level. In addition, it is recommended that some work with approximate numbers and operations with them be included in the work of the fifth grade.

[11] *Matematika v shkole*. Number 4, July-August, 1959, p. 2.

TABLE II

TOTAL TIME ALLOTTED INDIVIDUAL MATHEMATICAL DISCIPLINES IN THE TEN-YEAR AND ELEVEN-YEAR SCHOOLS

Subject	Ten-Year School		Eleven-Year School*	Transitional Period†
	Class Hrs.‡	Homework Hrs.	Class Hrs.	Class Hrs.
Arithmetic (with informal geometry)	792	—	792	792
Arithmetic (systematic course)	264	111	284	284
Algebra (and elementary functions)	462	228	551	469
Geometry	346	164	440	404
Trigonometry	116	55	0§	118
Total Time Allotted Mathematics	1980 hours	558 hours	2067 hours	2067 hours
Per Cent of All Hours in All subjects	20.1%	—	17.8%	17.8%

* City schools offering industrial instruction.

† City schools offering industrial instruction.

‡ A "class hour" is 45 minutes long at all levels.

§ Trigonometric topics are subsumed under "Algebra and Elementary Functions" and "Geometry" in the eleven-year organization.

Although not directly reflected in the major topic headings cited in Table III, topics from elementary geometry are distributed throughout the fifth grade program. Examples of such topics include the volumes of rectangular parallelepipeds and cubes, the areas of rectangles and squares, and perimeter and circumference. Geometric topics formerly covered but now omitted include the area of a circle and the surface area and volume of a right circular cylinder.[12]

Revisions in the algebra program also reflect the polytechnic "trend." The most significant revision is the early emphasis upon equations and their solution. Although equations were mentioned during the first weeks of the older fifth grade program, they were not treated in detail until the second semester of grade VI. Under the new program, sustained attention is to be given the equation early in both the fifth and sixth grades.[13] The early introduction of equations will permit the use of practical problems rather than the long series of abstract exercises which formerly characterized sections devoted to identity transformations upon algebraic expressions.

A second significant revision is evident in grade VII. Work with simple graphs apparently is considered to be of sufficient polytechnic

[12] *Ibid.*, p. 3.

[13] *Ibid.*

TABLE III

MATHEMATICS SYLLABUS FOR GRADES V–VIII OF THE SOVIET EIGHT-YEAR SCHOOL* (MAJOR TOPICS ONLY)

GRADE V

Arithmetic (6 hours per week, 216 hours in all)

1. Whole Numbers (36 hours)
2. Common Fractions (66 hours)
3. Decimal Fractions (72 hours)
4. Applications of Common and Decimal Fractions: Practical Work (30 hours)
5. Review (12 hours)

GRADE VI

(6 hours per week, 216 hours in all)

Arithmetic (4 hours per week in the first semester, 68 hours in all)

1. Approximate Computation (12 hours)
2. Per cent (18 hours)
3. Proportion: Direct and Inverse Proportion (28 hours)
4. Review (10 hours)

Algebra (4 hours per week in the second semester, 76 hours in all)

1. Algebraic Expressions: Equations (20 hours)
2. Positive and Negative Numbers (20 hours)
3. Operations upon Integral Algebraic Expressions (36 hours)

Geometry (2 hours per week, 72 hours in all)

1. Fundamental Concepts (16 hours)
2. Parallelism (18 hours)
3. Triangles (38 hours)
   (Practical work on location)

GRADE VII

(6 hours per week, 216 hours in all)

Algebra (4 hours per week, 144 hours in all)

1. Equations of the First Degree in One Unknown with Numerical Coefficients (28 hours)
2. Factorization of Polynomials (44 hours)
3. Algebraic Fractions (40 hours)
4. Systems of Coordinates and Simple Graphs (12 hours)
5. Equations in Two Unknowns. Systems of Equations (20 hours)

Geometry (2 hours per week, 72 hours in all)

1. Quadrilaterals (24 hours)
2. The Area of Polygons. The Volume of Prisms (16 hours)
3. Circles (32 hours)
   (Practical Work)

GRADE VIII

(5 hours per week, 175 hours in all)

Algebra (3 hours per week in the first semester, 2 hours per week in the second, 87 hours in all)

1. Calculators: (The Slide Rule) (8 hours)
2. Square and Cubic Roots (20 hours)
3. Equations and Systems of Equations of the Second Degree (32 hours)

4. Functions and Graphs (18 hours)
5. Review (9 hours)

Geometry (2 hours per week in the first semester, 3 hours per week in the second, 88 hours in all)

1. Proportional Segments. Similar Figures (30 hours)
2. Trigonometric Functions of an Acute Angle (12 hours)
3. Inscribed and Circumscribed Polygons (16 hours)
4. Information about Solid Geometry (15 hours)
5. Review (15 hours)

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* *Matematika v shkole*, No. 4, July–August, 1959, pp. 5–10.

importance to warrant special attention in the syllabus. At least a section so named has been added.

The practical significance of the elementary algebra program has been enhanced by the addition of a section entitled "Calculators (The Slide Rule)" at the eighth grade level. Formerly, work with the slide rule was found only at the end of the ninth grade. Eighth grade work with the slide rule is confined to techniques of calculation. Theoretical considerations are now delayed until grade X. The explanatory note to the project syllabus recommends that slide rule techniques introduced in the eighth grade mathematics program be applied and extended in physics, chemistry, and other related disciplines.[14]

In geometry, the polytechnic trend has had a consolidating effect. Topics formerly listed separately have been combined, e.g., "Proportional Segments" and "Similarity." In some instances, topics once studied in higher grades have been simplified and transferred to lower levels. Changes in grade placement were necessitated, for the most part, by the requirement that the eight-year compulsory program be reasonably complete polytechnically. For example, ten-year school pupils studied plane geometry in grades VI through VIII and solid geometry in grades IX and X. In the new syllabus, certain topics from solid geometry have been incorporated into the plane geometry program. Soviet educators explain that the actual integration of plane and solid geometry has not been attempted for two reasons:

1. It is difficult to carry on instruction in the same subject on two distinct logical levels simultaneously.
2. So many new concepts are introduced at the early stages of plane geometry that to include topics from solid geometry would burden the pupil unduly.[15]

On the other hand, solid geometry topics could not be grouped together at the end of the plane geometry course since the time avail-

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[14] *Ibid.*
[15] *Ibid.*

able there was hardly sufficient. For these reasons, topics from solid geometry have been divided into two groups. The first consists of topics related to the properties and measures of everyday solids, the second of questions concerning the mutual positions of lines and planes in space. The first of these groups is to be studied in grade VII in connection with the study of plane area.[16] Special emphasis is to be given solids studied in the physics course.

The second group of topics has been added at the end of the eighth grade program under the heading "Information About Solid Geometry." Here pupils receive propaedeutic information concerning spatial parallelism, perpendicularity, and the metric properties of common solids. As might be expected, models, practical examples, and examples from industry, agriculture, and construction are recommended highly as means to effective instruction.[17]

The proposed mathematics program of the three-year school is somewhat less polytechnic than that of the eight-year school. In some respects, the program appears more theoretical, more academic than latter portions of the discarded ten-year school program.

Trigonometry as a distinct discipline has been dropped from the curriculum. Instruction will be given in only two areas—"Algebra and Elementary Functions" and "Geometry." Portions of trigonometry deemed related to the study of functions have been added to the algebra program, e.g., circular functions. Trigonometric topics of a geometric nature are found in the geometry program, e.g., the solution of triangles.

In algebra, several topics formerly included in the ten-year syllabus have been discarded entirely, e.g., inequalities of 2nd degree, "Permutations and Newton's Binomial Theorem." Other topics once listed individually have been diluted and subsumed under related headings, e.g., "Complex Numbers."[18] A few new theoretical topics have been added. Pupils will receive instruction in the fundamentals of vector algebra in grade IX in connection with the topic "Trigonometric Functions of an Arbitrary Angle."[19] The concepts and techniques introduced here will be applied in the study of circular functions in grade IX and in the first part of grade X.

In grade XI, pupils first will study the limit concept and then the rudiments of differential calculus. Special emphasis will be given the practical implications of the calculus. Work with the derivative will be followed by a section devoted to the analysis of functions. Here students will apply the concept of derivative to the problems of sketching curves and the graphical solution of equations.

[16] *Ibid.*
[17] *Ibid.*, p. 4.
[18] *Ibid.*, p. 4.
[19] *Ibid.*, p. 12.

TABLE IV

MATHEMATICS SYLLABUS FOR THREE-YEAR SCHOOLS (CITY SCHOOLS OFFERING INDUSTRIAL INSTRUCTION)* (MAJOR TOPICS ONLY)

GRADE IX

(4 hours per week, 156 hours in all)

Algebra and Elementary Functions, (4 hours per week in the first quarter, 2 hours per week in the remaining quarters, 96 hours in all)

1. Powers and Roots (26 hours)
2. Equations and Inequalities (26 hours)
3. Trigonometric Functions of an Arbitrary Angle (20 hours)
4. Relations Between the Trigonometric Functions of the Same Angle (10 hours)
5. Conversion Formulas and their Corollaries (14 hours)

Geometry (Plane) (2 hours per week in the 2nd, 3rd, and 4th quarters)

1. Locus. Geometric Transformations (30 hours)
2. Metric Relations in a Circle and in a Triangle (30 hours)

GRADE X

Algebra and Elementary Functions (2 hours per week, 78 hours in all)

1. Trigonometric Addition Theorems and their Corollaries (38 hours)
2. Exponential and Logarithmic Functions (40 hours)

Geometry (Solid) (2 hours per week, 78 hours in all)

1. The Structure of the Solid Geometry Course (Axioms, definitions and theorems in mathematics) (8 hours)
2. Parallelism in Space (20 hours)
3. Perpendicularity in Space (16 hours)
4. Locus and Geometric Transformations in Space (14 hours)
5. Polyhedra (20 hours)

GRADE XI

Algebra and Elementary Functions (2 hours per week, 70 hours in all)

1. Functions and Limits (20 hours)
2. The Derivative (16 hours)
3. The Analysis of Functions (12 hours)
4. Equations of Higher Degree (10 hours)
5. Review (12 hours)

Geometry (2 hours per week, 70 hours in all)

1. The Measurement of Quantities in Geometry (14 hours)
2. Solids of Revolution and Their Surface Areas (18 hours)
3. The Measurement of Volume (18 hours)
4. Review (20 hours)

* *Matematika v shkole*, No. 4, July–August, 1959, pp. 10–14.

The geometry program of the three-year school is both a continuation and extension of the program of the eight-year school. Pupils will study topics from plane geometry in grade IX, e.g., "locus, Geometric Transformations," "Metric Relations in a Triangle and in a Circle." Work specified at this level includes the solution of right and

TABLE V

MATHEMATICS SYLLABUS FOR GRADES V–X OF THE SOVIET TEN-YEAR SCHOOL* (MAJOR TOPICS ONLY)

GRADE V (age 11–12)

Arithmetic (6 hours per week, 198 hours in all)

1. Whole Numbers (20; 8)†
2. Divisibility of Numbers (20; 8)
3. Common Fractions (90; 36)
4. Decimal Fractions (50; 20)
5. Practical Work (6)
6. Review (12; 6)

GRADE VI (age 12–13)

(6 hours per week, 198 hours in all)

Arithmetic (4 hours per week in first semester, 66 hours in all)

1. Per cent (20; 10)
2. Proportion, Direct and Inversely Proportional Quantities (36; 16)
3. Review (14; 7)

Algebra (4 hours per week in the second semester, 66 hours in all)

1. Algebraic Expressions. Equations (16; 8)
2. Positive and Negative Numbers (20; 10)
3. Operations on Integral Algebraic Expressions (30; 15)

Geometry (2 hours per week, 66 hours in all)

1. Basic Concepts (14; 7)
2. Parallelism (16; 8)
3. Triangles (32; 16)
4. Practical Activity (4)

GRADE VII (age 13–14)

(6 hours per week, 198 hours in all)

Algebra (4 hours per week, 132 hours in all)

1. Factorization of Polynomials (36; 18)
2. Algebraic Fractions (24; 12)
3. Equations of the First Degree in One Unknown (34; 17)
4. Equations in Two Unknowns. Systems of Equations (28; 14)
5. Review (10; 5)

Geometry (2 hours per week, 66 hours in all)

1. Quadrilaterals (26; 13)
2. Circles (34; 17)
3. Practical Activity (6)

GRADE VIII (age 14–15)

(6 hours per week, 198 hours in all)

Algebra (4 hours per week in the first semester, 3 hours per week in the second, 116 hours in all)

1. Powers and Roots (44; 22)

* *Programmy srednei shkoly na 1959–60 uchebnyi god. Matematika.* Moscow: Uchpedgiz, 1959. Pages 25–45.

† Here and elsewhere the first number in the parentheses indicates the hours spent in class; the second, the hours spent on homework.

2. Equations of the Second Degree and those Reducible to this Form (42; 21)
3. Functions and Graphs (12; 6)
4. Systems of Equations of Second Degree (18; 9)

Geometry (2 hours per week in the first semester, 3 hours per week in the second, 82 hours in all)

1. Ratio and Proportionality of Segments (10; 5)
2. Homotheticity and Similarity (18; 9)
3. Metric Relations in a Triangle and in a Circle (36; 18)
4. Measurement of the Areas of Polygons (14; 7)
5. Practical Activity (4)

GRADE IX (age 15–16)

(6 hours per week, 198 hours in all)

Algebra (2 hours per week, 66 hours in all)

1. Limits (6; 3)
2. Progressions (14; 7)
3. Exponential and Logarithmic Functions. Logarithms (40; 20)
4. Practical Activity in Calculating with the Slide Rule (6)

Geometry (2 hours per week, 66 hours in all)

1. Regular Polygons (12; 6)
2. Length of Circumference and the Area of a Circle (10; 5)
3. Solid Geometry (40; 20)
4. Practical Activity (4)

Trigonometry (2 hours per week, 66 hours in all)

1. Trigonometric Functions of an Arbitrary Angle (10; 5)
2. Algebraic Relations Between Trigonometric Functions of the same Angle. Conversion Formulas (16; 8)
3. Trigonometric Functions of a Numerical Argument (16; 8)
4. Additional Theorems and their Corollaries (24; 12)

GRADE X (age 16–17)

(6 hours per week, 198 hours in all)

Algebra (2 hours per week in the first semester and 3 hours per week in the second, 82 hours in all)

1. Permutations and Newton's Binomial Theorem (12; 6)
2. Complex Numbers (12; 6)
3. Inequalities (30; 15)
4. Equations of Higher Degree (12; 6)
5. Review (16; 8)

Geometry (2 hours per week, 66 hours in all)

1. Polyhedra (28; 14)
2. Solids of Revolution (20; 10)
3. Review and the Solution of Problems (18; 9)

Trigonometry (2 hours per week in the first semester, 1 hour per week in the second, 50 hours in all)

1. The Solution of Triangles (24; 12)
2. Practical Activity in the Field (6)
3. Review of Trigonometry and the Solution of Problems on Trigonometry and on Geometry with Application of Trigonometry (20; 10)

oblique triangles using trigonometric tables and the slide rule.[20] In grade X, topics to be studied are three-dimensional, e.g., parallelism and perpendicularity in space. The eleventh grade program is concerned with the rigorous treatment of questions of plane and solid mensuration, especially the derivation of common mensuration formulas for curvilinear figures, polyhedra, and solids of revolution.[21]

The sustained emphasis given the concept of geometric transformation in both the eight-year syllabus and the three-year syllabus appears to be a continuation of a recent Soviet trend toward "modern" geometry. This trend was first evidenced in the old syllabus by the addition of the major topic "Homotheticity and Similarity."[22] Although these early efforts met with little success, Soviet mathematics educators apparently feel the transformational approach worthy of a trial at a more advanced level.

No work with integral calculus, the elements of analytic geometry, or certain other "modern" topics can be found in either the algebra or geometry syllabus. According to the explanatory note accompanying the project syllabus, "at the present time, their inclusion was not possible."[23]

In summary, changes in the Soviet mathematics program enacted in response to Chairman Khrushchev's recent proposals appear to emphasize the practical, the polytechnic side of mathematics at the elementary levels. The advanced levels, however, remain substantially academic. Soviet pupils will study arithmetic, elementary algebra, plane geometry, and miscellaneous topics from solid geometry and trigonometry in the compulsory eight-year school. The mathematics curriculum of the non-compulsory three-year school will consist of two courses: "Algebra and Elementary Functions" and "Geometry." Trigonometry as a *distinct* discipline has been eliminated. A number of significant changes in content and sequence are evident in the new curriculum. These changes are summarized in Table VII.

Timewise, the status of mathematics appears to have been improved by the reorganization. Pupils completing the full-time eleven-year program will devote 2067 hours to the study of mathematics. Ten-year school pupils studied mathematics for only 1980 hours.

Facts presented would seem to indicate that the new Soviet program will be both realistic and challenging. In general, it would appear to be a step forward. Final evaluation, however, must await preparation and publication of new Soviet texts and the distribution

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[20] *Ibid.*
[21] *Ibid.*, p. 5.
[22] *Programmy . . . , op. cit.*, p. 36.
[23] *"Proekt programmy . . . ," op. cit.*, p. 5.

of data concerning enrollment in and graduation from the non-compulsory three-year school.

TABLE VI

TRANSITIONAL MATHEMATICS SYLLABUS FOR THREE-YEAR SCHOOLS (CITY SCHOOLS OFFERING INDUSTRIAL INSTRUCTION) OPERATING WITH CURRENT TEXTS* (MAJOR TOPICS ONLY)

GRADE IX

(4 hours per week, 156 hours in all)

Algebra (2 hours per week, 78 hours in all)

1. Review of the Work of Grade VIII (6 hours)
2. Limits (8 hours)
3. Progressions (14 hours)
4. Exponential and Logarithmic Functions. Logarithms (40 hours)
5. Practical Activity with the slide Rule (10 hours)

Geometry (2 hours per week in the first semester, 34 hours in all)

1. Review of the Work of Grade VIII (6 hours)
2. Regular Polygons (12 hours)
3. Length of Circumference and the Area of a Circle (12 hours)
4. General Survey of the Plane Geometry Course (4 hours)

Trigonometry (2 hours per week in the second semester, 44 hours in all)

1. Trigonometric Functions of an Arbitrary Angle (10 hours)
2. Algebraic Relations between Trigonometric Functions of the Same Angle. Conversion Formulas (16 hours)
3. Trigonometric Functions of a Numerical Argument (18 hours)

GRADE X

(4 hours per week, 156 hours in all)

Algebra (2 hours per week in the third quarter and 1 hour per week in the fourth, 32 hours in all)

1. Permutations and Newton's Binomial Theorem (14 hours)
2. Complex Numbers (12 hours)
3. The Solution of Binomial and Trinomial Equations of the 3rd, 4th, and 6th Degrees. (6 hours)

Geometry (2 hours per week in the 1st, 2nd, and 4th quarters and 1 hour per week in the third, 68 hours in all)

1. The Mutual Positions of Lines and Planes in Space (40 hours)
2. Polyhedra (28 hours)

Trigonometry (2 hours per week in the first semester and 1 hour per week in the second, 56 hours in all)

1. The Addition Theorems and their Corollaries (24 hours)
2. The Solution of Triangles (24 hours)
3. Practical Activity in the Field (6 hours)
4. Review (2 hours)

GRADE XI

(6 hours per week, 140 hours in all)

Algebra (2 hours per week in the first semester, 1 hour per week in the second, 52 hours in all)

1. Inequalities and the Analysis of Equations (24 hours)
2. Equations of Higher Degree (10 hours)
3. Review and the Solution of Problems (18 hours)

Geometry (2 hours per week, 70 hours in all)

1. Solids of Revolution (24 hours)
2. The Solution of Problems on Geometry and on Geometry with Applications of Trigonometry (30 hours)
3. Review of the Geometry Course (16 hours)

Trigonometry (1 hour per week in the second semester, 18 hours in all)

1. Review of the Trigonometry Course (18 hours)

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* *Matematika v shkole*, No. 5, September–October 1959, pp. 55–56.

TABLE VII

SUMMARY OF DIFFERENCES IN THE MATHEMATICS SYLLABI OF SOVIET TEN-YEAR AND ELEVEN-YEAR SCHOOLS

Grade	Arithmetic	Algebra	Geometry	Trigonometry
V	Time allotted "Decimal Fractions" increased at the expense of "Common Fractions"			
	Section on "Applications of Common and Decimal Fractions . . . " added			
	Elimination of the major topic "Divisibility of Numbers"			
VI	Addition of the major topic "Approximate Computation"			
		Early emphasis upon equations		
VII		Early emphasis upon equations	Solid mensuration studied along with plane area	
		Addition of the major topic ". . . Simple Graphs"		
VIII		Addition of the major topic "Calculators (the Slide Rule)"	Combination of the major topics "Proportionality of Segments" and "Similarity"	
			Addition of work in solid geometry	
IX		Addition of the functional aspects of trigonometry to the algebra program	Addition of the geometric aspects of trigonometry to the geometry program	Elimination of trigonometry as a distinct discipline
		Introduction of the elements of vector algebra	Plane geometry studied throughout grade XI	
X		Elimination of the major topics "Inequalities (of the 2nd degree)" and "Permutations and Newton's Binomial Theorem"	Solid geometry studied throughout grade X	
		Dilution of the topic "Complex Numbers"		
XI		Addition of work with elementary differential calculus	Rigorous derivation of common mensuration formulas	

A Study of the Relationship of Fundamental Skills Measured by the *National Merit Scholarship Qualifying Test* to Natural Sciences Reading Ability

Billy G. Aldridge* and Kenneth E. Anderson

Dean, School of Education, University of Kansas, Lawrence, Kansas

Introduction

In order to participate effectively in a technological world, people have needed to understand scientific principles. It has been generally accepted that by using the scientific method, people have developed, to some degree, the ability to think critically; an absolute requirement for a properly functioning democracy. Having recognized the importance of good science curricula and instruction, research workers in education have studied a variety of problems in this area.

Some investigators have examined the effect of intelligence test scores on achievement in science.[1] The objectives of science instruction have been studied to ascertain the relative contribution of certain scientific or related factors to the fulfillment of these objectives.[2] However, few investigators have considered the effect on general achievement in science, by specific factors outside the area of science. Because a major factor related to achievement in science has been the ability to read science materials with understanding, the writers examined some fundamental skills to find how they are related to Natural Sciences Reading ability.

The Problem

The problem of this study was to find how four fundamental skills, as measured by the *National Merit Scholarship Qualifying Test*,[3] affected Natural Sciences Reading ability. The four fundamental skills were as follows:

1. *English Usage.* This involves some of the basic elements in correct and effective writing: punctuation, usage, capitalization, spelling, diction, phraseology, and organization.
2. *Mathematics Usage.* This involves both general aptitude for the study of mathematics and the ability to solve practical quantitative problems that occur in other areas of knowledge, such as natural sciences, the social studies, industrial arts, and agriculture.

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* This article is based on the findings of the unpublished Master of Science in Education thesis completed by Billy G. Aldridge at the University of Kansas in May 1959, under the direction of Dean Kenneth E. Anderson.

[1] Marjorie Ruth Porter and Kenneth E. Anderson, "A Study of the Relationship of Specified Abilities in Chemistry to Each Other and to Intelligence." *Science Education*, 43 (February, 1959) 12–19.

[2] Kenneth E. Anderson, "The Relative Achievements of the Objectives of Secondary School Science in a Representative Sampling of Fifty-six Minnesota Schools." Unpublished doctoral disseration, University of Minnesota, 1949, 288 pp.

[3] *National Merit Scholarship Qualifying Test.* Science Research Associates, U.S.A., 1958.

3. *Social Studies Reading.* This concerns the student's ability to interpret and evaluate representative reading selections taken from magazines and newspaper articles on social problems, and from literature of the social studies in general. Emphasis is on understanding ideas, perceiving opinions, grasping implied meanings, and making subjective evaluations.
4. *Word Usage.* This is concerned with general vocabulary and the ability to recognize the meaning of words.

Natural Sciences Reading is concerned with the ability to read materials used in the natural sciences, from articles in newspapers and periodicals, and from relatively non-technical scientific literature. It is concerned with details and exact meanings. It involves close reasoning and rigid mathematical logic.

The Sample

The sample consisted of 300 students who took the *National Merit Scholarship Qualifying Test* in 1958. The writers had access to approximately 7,000 sets of standard scores from 312 different Kansas high schools.[4] The sample of 300 sets of scores was selected by taking the scores of the first student on each list of 300 of the 312 high school score lists. Students were listed alphabetically. Sex was not a factor in the selection. Five scores were recorded for each student. All were standard scores; not raw scores. Each score was a measure of one of the five factors under consideration.

Procedure and Results

Since the purpose of this study was to determine relationships of four fundamental skills to Natural Sciences Reading ability, correlational and multiple regression analysis techniques were used. Results by these methods are not critically affected by non-normal data; however, the t tests and F tests involved do require somewhat normal data. It has been proved that no serious error for a slight departure from normality is introduced into the significance levels when the t test and F test are used.[5]

In Table 1, skewness and kurtosis values for each sub-test indicate that the data were nearly normal. The upper and lower limits on skewness were $+0.22$ and -0.19 respectively. Kurtosis values were between the limits of .238 and .270; whereas a normal curve has a kurtosis of .263. Four of the five sub-tests were skewed negatively. One of the tests was skewed positively. Distributions of two of the sub-tests were platykurtic.

Other statistics which have been recorded in Table 1 are the mean, median, standard deviation, and four common centile points.

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[4] Kenneth E. Anderson, University of Kansas General Research Project Number 4542-5570.

[5] W. G. Cochran, "Some Consequences When the Assumptions for the Analysis of Variance Are Not Satisfied." *Biometrics*, 360 (March, 1947) 22-28.

Table 2 indicates the values of the various correlations of the sub-tests with the test on Natural Sciences Reading. Table 3 indicates the significance of the differences among the various correlations. Table 4 indicates the proportion of the variance mathematically accounted for in the various correlations where there were N observations on the dependent variable.

TABLE 1

MEASURES OF CENTRAL TENDENCY, VARIABILITY, SKEWNESS, AND KURTOSIS FOR THE DISTRIBUTIONS OF SUB-TEST STANDARD SCORES

Sub-test	Mean	Md.	S.D.	Q_3	Q_1	C_{90}	C_{10}	Sk	Ku
X_1 English Usage	18.57	18.22	4.71	22.17	15.80	25.00	12.60	+.22	.257
X_2 Mathematics Usage	17.66	17.44	6.07	20.77	13.37	25.20	9.83	−.03	.241
X_3 Social Studies Reading	18.86	19.00	5.38	22.13	15.36	25.90	11.70	−.19	.238
X_4 Word Usage	19.32	19.34	5.24	23.50	15.97	25.73	11.50	−.01	.265
Y Natural Sciences Reading	19.23	19.31	5.87	23.33	15.28	26.67	11.82	−.04	.270

TABLE 2

CORRELATIONS OF FOUR SUB-TESTS WITH THE NATURAL SCIENCES READING TEST

Correlation Between	$N=300$	r
English Usage and Natural Sciences Reading		
Variable X_1	Variable Y	.5559*
Mathematics Usage and Natural Sciences Reading		
Variable X_2	Variable Y	.5215*
Social Studies Reading & Natural Sciences Reading		
Variable X_3	Variable Y	.6322*
Word Usage and Natural Sciences Reading		
Variable X_4	Variable Y	.6567*

* Significant at the 1 per cent level.

On the basis of the computed values in Tables 2, 3, and 4, it was possible to make the following summarization:

1. The proportion of the variance mathematically accounted for indicated that ability in Natural Sciences Reading had been accompanied by abilities in: (1) English usage, (2) mathematics usage, (3) social studies reading, and (4) word usage, according to the relative weights of 1.14:1.00:1.47:1.59.
2. The significance of the differences of the intercorrelations of sub-tests X_1, X_2, X_3, and X_4 with Y indicated that ability in Natural Sciences Reading had been accompanied to:
   - A. A greater degree by ability in word usage than in English usage. The F ratio was significant at the 1 per cent level.
   - B. A greater degree by ability in word usage than in mathematics usage. The F ratio was significant at the 1 per cent level.
   - C. The same extent by ability in word usage and social studies reading. The F ratio was not significant at the 5 per cent level.
   - D. A greater degree by ability in social studies reading than in mathematics usage. The F ratio was significant at the 5 per cent level.
   - E. A greater degree by ability in social studies reading than in English usage. The F ratio was significant at the 5 per cent level.
   - F. The same extent by ability in English usage and mathematics usage. The F ratio was not significant at the 5 per cent level.

TABLE 3

SIGNIFICANCE OF THE DIFFERENCES AMONG THE VARIOUS CORRELATIONS WHERE THERE WERE N OBSERVATIONS ON THE DEPENDENT VARIABLE*

High Correlation Listed First	F	Probability
(Y—4) (Y—1), (.6567) (.5559)	8.73	$p < .01$
(Y—4) (Y—2), (.6567) (.5215)	9.69	$p < .01$
(Y—4) (Y—3), (.6567) (.6322)	.49	$p > .05$
(Y—3) (Y—2), (.6322) (.5215)	6.66	$.05 > p > .01$
(Y—3) (Y—1), (.6322) (.5559)	4.16	$.05 > p > .01$
(Y—1) (Y—2), (.5559) (.5215)	.51	$p > .05$

* Hotelling's Method.

TABLE 4

PROPORTION OF VARIANCE MATHEMATICALLY ACCOUNTED FOR IN THE VARIOUS CORRELATIONS WHERE THERE ARE N OBSERVATIONS ON THE DEPENDENT VARIABLE

Correlations	Squared	Percentage or Weight	
(Y—1)	.3090	21.88	1.14
(Y—2)	.2720	19.26	1.00
(Y—3)	.3997	28.31	1.47
(Y—4)	.4313	30.55	1.59
	1.4120	100.00	

TABLE 5

THE INFLUENCE OF THE INDEPENDENT VARIABLES UPON THE VARIANCE OF THE DEPENDENT VARIABLE—ABILITY IN NATURAL SCIENCES READING

Variable	Regression Coefficient* Squared or k Squared	Percentage or Weight	
X_2 Ability in mathematics usage	.0437	15.98	1.00
X_3 Ability in social studies reading	.0825	30.16	1.89
X_4 Ability in word usage	.1473	53.86	3.37
Total	.2735	100.00	

* All regression coefficients listed here are significantly different from zero at the 1 per cent level.

If we consider (Y) the measure of the ability to read natural sciences as the dependent variable, and (X_1) the measure of ability in English usage, (X_2) the measure of ability in mathematics usage, (X_3) the measure of ability in social studies reading, and (X_4) the

measure of ability in word usage, as independent variables, the multiple correlation coefficient was:

$$R_{y.1234} = .7367 \qquad p < .01$$

The number of cases entering into the computation was 300. The sample of 300 was the same as that selected for the intercorrelations.

When the multiple correlation coefficient is squared, an index is obtained of the proportion of the variance in the dependent variable which is mathematically accounted for by the linear combination of the independent variables. In the above correlation this proportion becomes 54.27 per cent.

The percentage of influence of each of the independent variables upon the variance of the dependent variable is given by the squares of the standard partial regression coefficients. The values and the percentages or weights are given in Table 5.

Insofar as the factors considered contribute toward ability in Natural Sciences Reading, ability in mathematics usage, ability in social studies reading, and ability in word usage contributed with the relative weights of 1.00:1.89:3.37. The standard partial regression coefficient for ability in English usage was not significantly different from zero at the 1 per cent level.

Summary

Correlational analysis and multiple regression analysis were used to determine the relationship of four fundamental skills to Natural Sciences Reading ability.

Measures of each variable were taken from sub-tests of the *National Merit Scholarship Qualifying Test.* Using a sample of 300 cases, various statistics were computed.

Using standard scores, correlations of the four sub-tests with the test on Natural Sciences Reading were computed. From these correlations it was possible to determine the relative contributions, in terms of variance, of the four variables to the remaining variable, Natural Sciences Reading.

By using the various intercorrelations in a matrix inversion, it was possible to determine the relative contribution of the independent variables to ability in Natural Sciences Reading, the dependent variable. This involved calculations of the multiple correlation coefficient and standard partial regression coefficients. Tests of significance were used extensively. Regression coefficients were not accepted as being significantly different from zero unless the t test probability level was less than 1 per cent.

The results of the calculations revealed that ability in Natural

Sciences Reading was accompanied most intensely by abilities in word usage and social studies reading, and least intensely by abilities in mathematics usage and English usage.

The multiple correlation indicated that 54.27 per cent of the variance had been accounted for by a linear combination of the three remaining independent variables. The percentage of influence of each of the factors as revealed by the squares of the standard partial regression coefficients indicated that ability in word usage contributed the most to Natural Sciences Reading ability. Of the remaining variables, ability in social studies reading contributed the most, and ability in mathematics usage contributed the least to Natural Sciences Reading ability. English usage did not contribute significantly to Natural Sciences Reading ability.

Natural Sciences Reading ability is a critical learning factor in science. The fact that word usage and social studies reading were high contributors to Natural Sciences Reading ability, provides a guide for emphasis in preparing children for the study of natural sciences. It is significant that mathematics usage was the least important factor of the three in terms of its contribution to Natural Sciences Reading ability. The fact that English usage (punctuation, spelling, capitalization, diction, and organization) contributed nothing to Natural Sciences Reading ability is not particularly alarming but puzzling. Perhaps a larger sample might have given different results.

IMPROVED DEVICE PHOTOGRAPHS 50 FRAMES OF HEART A SECOND

X-ray photographs of the heart and great blood vessels can now be taken at the fantastic rate of 50 frames a second.

This increase over the standard six to 12 frames a second is due largely to a cine attachment.

The process of taking X-ray photographs of the heart and major blood vessels after injection of a radio-opaque dye is called angiocardiography. It is an exacting procedure which has had a number of drawbacks.

For instance, angiocardiography was formerly performed by injecting dye into a vein and waiting for it to reach the heart. However, by that time, it was diluted to such an extent that it gave only a hazy image.

The next method tried was to inject dye through a catheter (narrow tube) lying in a chamber of the heart. Even then, as the dye flowed out of the catheter rather slowly, it was diluted by the blood and diffused so rapidly throughout the heart that again a clear picture was extremely difficult to obtain.

With a mechanical rapid dye injector, the full charge of concentrated dye is shot out of the catheter within one to two seconds, giving a sharp contrast which is photographed as it courses through the heart.

The cine attachment itself is a conventional X-ray tube and fluoroscopic screen, placed below and above the patient on the treatment table. It has, in addition, a five-inch image-intensifier tube above the screen. This greatly strengthens the image, and permits motion pictures to be taken with only a fraction of the amount of X-rays ordinarily required. A motion-picture camera is located at the top of the tube and its shutter operates only when the X-ray current is on.

Generalization in Geometry

Charles H. Butler

Western Michigan University, Kalamazoo, Michigan

A greal deal is being said these days about the reshaping and modernization of high school mathematics, and this is proper and wholesome. A subject which is undergoing such rapid and radical expansion as mathematics needs to be continually reexamined at all levels. High school geometry is no exception to this, and it is receiving its share of attention. In its present form it has its honest critics and its honest defenders. Recommendations range from better teaching of the present geometry course to radical revision of the postulates and a treatment of the subject more in line with contemporary mathematical ideas. At present nobody knows for sure just what the geometry taught in high school a few years hence will be like, though it does seem almost certain that some changes will come about. In the meantime, until a new pattern emerges and gains wide acceptance, it seems inevitable that the course as represented in the present standard textbooks will continue to predominate.

The purpose of this article is to suggest one means or device for strengthening one important mathematical concept which is too much neglected but which can be pointed up easily and forcibly by geometry teachers wholly within the framework of the present conventional courses in geometry. This concept is the concept of generality and relatedness. The means or the device is the generalization of a group of propositions into a single comprehensive proposition under which all the other propositions in the group become special cases. This sometimes involves the broadening of definitions and sometimes even the invention of a new theorem. It is a good mathematical device because it forces students to clarify their geometric concepts, to examine and compare the geometric properties of the figures involved more closely and more critically than they had needed to do before, to clarify in their minds the concept of a generalization, and to test critically each special theorem to make sure whether or not it is actually a special case under the general proposition. It is a good pedagogical device because it practically always captures and holds the interest of students. It involves an element of discovery and reduces the likelihood of boredom. Also it serves to connect and give organization to sets of separate but related theorems, and this, in turn, gives some assurance that they will be remembered correctly. For some reason textbooks make very little capital of this device, but it can be used to advantage by any good teacher.

This is not a new device. It has long been used by some teachers and it was discussed and advocated in an excellent article nearly

thirty years ago.[1] Therefore what is said here will not be new. It is believed, however, that even now many geometry teachers do not make much use of this device, and so fail to gain the educational dividend that it could yield. The present article is written solely to bring the device again to the attention of teachers with the hope that it may come to be used more widely than it has been in the past.

The two examples which are given here will serve to illustrate how a set of theorems can be generalized; that is, how two or more theorems developed indiviually as separate theorems can be shown to be actually special cases of a single more general theorem.

I. Consider the following theorems which are usually developed separately:

(a) *The area of a square is equal to the square of any side.* This amounts to saying that the area of the square is equal to the product one side by itself (usually assumed and not stated explicitly as a separate theorem. A square can be regarded as a special kind of rectangle in which the sides are all equal).

(b) *The area of a rectangle is equal to the product of its base and its altitude* (sometimes taken as a definition of the area of a rectangle. A rectangle can be regarded as a special kind of parallelogram in which the angles are all right angles).

(c) *The area of a parallelogram is equal to the product of its base and its altitude* (a parallelogram can be regarded as a special kind of trapezoid in which we have not only the bases parallel, but also the other two sides parallel to each other. This requires that a trapezoid be defined merely as a plane quadrilateral with two sides parallel. Unfortunately, most textbooks use a more restricted definition which does not permit the full generalization suggested here. But since definitions are arbitrary, the restriction may be at least temporarily removed even if only to make this interesting generalization possible).

(d) *The area of a triangle is equal to half the product of its base and its altitude* (a triangle can be regarded as a special or limiting case of a trapezoid in which the length of one base is taken to be zero).

(e) *The area of a trapezoid is equal to half the product of its altitude and the sum of its bases.*

Here we have five theorems, or rules for finding areas, which are either assumed or proved in the order given. Under the broadened definition suggested, the trapezoid is the most general of the five kinds of figures to which the theorems refer, and each of the others can be regarded as a special or limiting case of a trapezoid. That is to say, each of the others can be regarded as a trapezoid for which some additional restrictions are prescribed but which still has all the defining characteristics of a trapezoid. Hence the formula for the area of a trapezoid should yield in every case, under the appropriate special restrictions, the formula for the area of the figure in question. That it does exactly this can be seen as follows:

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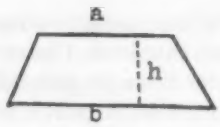
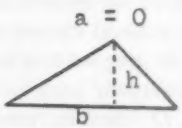
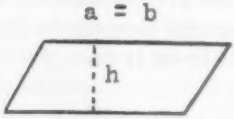
[1] F. P. Hennessey: The Principle of Continuity, *The Mathematics Teacher*, vol. 24, January 1931, pp. 32–40.

(e) 

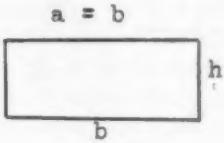
Trapezoid $\quad \text{Area} = \frac{1}{2}h(b+a)$

(d) 

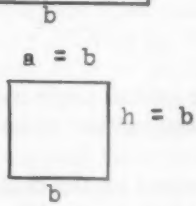
Triangle $\quad \text{Area} = \frac{1}{2}h(b+a) = \frac{1}{2}h(b+0)$
$= \frac{1}{2}h(\ b\ )$

(c) 

Parallelogram $\quad \text{Area} = \frac{1}{2}h(b+a) = \frac{1}{2}h(b+b)$
$= \frac{1}{2}h(\ 2b\ ) = hb$

(b) 

Rectangle $\quad \text{Area} = \frac{1}{2}h(b+a) = \frac{1}{2}h(b+b)$
$= \frac{1}{2}h(\ 2b\ ) = hb$

a) 

Square $\quad \text{Area} = \frac{1}{2}h(b+a) = \frac{1}{2}h(b+b)$
$= \frac{1}{2}b(\ 2b\ ) = bb \qquad = b^2$

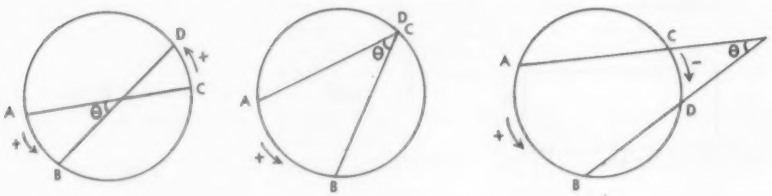
Thus in each special case the general formula for the area of a trapezoid yields the special formula for the area of the figure being considered.

II. Another and perhaps more interesting case involves a group of theorems related to the measure of angles formed by lines associated with a circle. These are commonly developed in the following order:

(a) *A central angle is measured by its intercepted arc.*
(b) *An inscribed angle is measured by half its intercepted arc.*
(c) *An angle formed by a tangent and a chord is measured by half its intercepted arc.*
(d) *An angle formed by two chords intersecting inside a circle is measured by half the sum of the intercepted arcs.*
(e) *An angle formed by two secants intersecting outside the circle is measured by half the difference of the intercepted arcs.*
(f) *An angle formed by a tangent and a secant which intersect outside a circle is measured by half the difference of its intercepted arcs.*
(g) *An angle formed by two tangents to a circle is measured by half the difference of its intercepted arcs.*

These theorems, as they are stated, all imply that one is to consider only the positive or absolute values of all arcs involved. Under this restriction they cannot all be subsumed under a single generalized theorem. But if the notion of *directed* arcs (clockwise, negative; counterclockwise, positive) were introduced, then each of these theorems would become a special case of the following general theorem: *The angle formed by two lines each of which cuts or is tangent to a circle is measured by half the* ALGEBRAIC *sum of the intercepted arcs.*

Thus if the arcs are taken to be AB and CD (that is, measured *from A to B* and *from C to D*) and if A and C are always taken on one line with B and D on the other, then the general formula $\theta=\frac{1}{2}(AB+CD)$ will yield the appropriate measure of θ in each case.



In case (a), where the radii forming the central angle are considered to be parts of intersecting diameters, and in case (d) both of the arcs AB and CD are positively directed.

In cases (b) and (c), where the lines intersect on the circle, points C and D coincide, and the measure of arc CD is zero, while AB may be taken to be positively directed.

In cases (e), (f), and (g), where the lines intersect outside the circle, if the arc AB is taken to be positively directed, then the arc CD will be negatively directed. The *algebraic* sum of these arcs gives, of course, the difference between their absolute values, as implied in the usual statements of the theorems.

Thus all the separate theorems listed here are subsumed under the general encompassing theorem stated above, and are special cases of it. This theorem probably will not be found in any of the standard textbooks on geometry, but this very fact, instead of being a disadvantage, might indeed give it additional interest to students.

By sharpening the definition of an angle and invoking the theory of limits, the general theorems of sets I and II above can be made also to yield respectively the theorem giving the formula for the area of a circle and a converse of the theorem which states that parallel lines intercept equal arcs on a circle.

Not all theorems, of course, lend themselves readily to such generalization, and the two sets exhibited above are perhaps the most

extensive examples to be found in the usual course in plane geometry. There are numerous cases, however, in which two or three theorems can be grouped in this manner and be subsumed under a single covering theorem. For example, the theorem which states that "*In any triangle the square of the side opposite an acute* (or obtuse) *angle is equal to the sum of the squares of the other two sides minus* (or plus) *twice the product of one of these two sides and the projection of the other side upon that one*" includes the Pythagorean Theorem as a special case. Later, in trigonometry, it can be pointed out that the law of cosines is merely a restatement (in the language of trigonometry) of the general theorem given above.

The instances which have been cited or suggested here have all been drawn from plane geometry. It should be noted that there are groups of theorems in solid geometry as well, which are susceptible to generalization in a similar way. This sort of generalization can do much to sharpen the space perception of students as well as to enhance their understanding of the relationships that exist among geometric configurations and among theorems.

It is important in all mathematical instruction to try to develop in the students a feeling for organization and relationships which may exist among different parts of the subject which they are studying. The device which is suggested in this article can contribute significantly toward this in plane geometry and, by counterpart, in solid geometry as well. Good teaching is not one thing but many, because learning and insight may come through a variety of avenues. The generalization of theorems, and the search for groups of theorems that can be so generalized, provides one avenue through which mathematical insight may be nurtured. It is good pedagogy and good mathematics, and it is worth trying.

LIQUID HELIUM 3 GIVES NEW THEORY HOW LIQUIDS ACT

Unusual properties of one of the rarest of all chemical elemental forms, helium of atomic weight 3, are giving scientists new ideas on why and how liquids are liquids.

At extreme temperatures near absolute zero (0 degrees Kelvin) (273 degrees below zero centigrade) helium engages in strange and puzzling antics. Ordinary helium of mass 4, ordinarily a gas at normal temperatures and pressures, become a liquid when chilled and remains a liquid even at absolute zero.

Physicists have been working with the mass three helium isotope at low temperatures, now that it has become available through the U. S. Atomic Energy Commission as the result of radioactive disintegration of tritium or triple weight hydrogen.

Unlike its heavier isotopic brother, helium 3 does not seem to exhibit superfluidity, which means the liquid sort of runs up hill. Sound is propagated strangely in ordinary liquid helium in two different ways, but the triple helium shows what theoretically is called zero sound.

Nutrition Experiments for the Classroom

Francis St. Andrew

Martin High School, Martin, Mich.

Purpose and Scope

Because of a lack of sufficient literature concerning laboratory experiments using small laboratory animals, a handbook on nutritional experiments for the classroom at different levels (of difficulty) is presented. Because of the inexperience of most school personnel in this field, types of animals used, handling animals, cages, feeding, keeping records, and actual experiments with results are included. The references at the end will be useful to those who desire more detailed information.

Animal experiments conducted by school groups will help to furnish the boys and girls with (a) a knowledge of proper and improper diets, (b) a knowledge of essential food nutrients, (c) the effect of an improved diet on growth, (d) experience in conducting animal experiments, and (e) a scientific method of working.

Experimenting with animals in the classroom presents a real challenge to the students as well as the teacher. Since concrete results are so vivid in a relatively short period of time in showing deficiencies as well as regaining normal health, much is gained through nutritional experimenting.

In the lower grades, the teacher, of necessity, will have to supervise closely all experimental work. However, the group must be given a feeling of responsibility in the experiment. In the high school, much of the responsibility can and should be placed upon the students.

When it has been decided to carry out an animal feeding experiment (fall or spring is probably the best time, as abrupt temperature changes are not so likely), complete arrangements must be carried out before animals arrive. Planning with the students on such matters as number and type of animals, cages, and diets (". . . should be composed of familar foods, since these will have greater educational value"[1]). Experiments should be planned for a relatively short period of time.

Part I. General Information

I. *Types of Animals Used*

The use of animals is an effective means of showing the results of deficient diets to boys and girls. Because other animals make use of food in much the same manner as man, animal experiments are an effective means of teaching nutrition. They are inexpensive, easy to

[1] Martha Potgieter, "Chick Growth Teaches Nutrition," *Journal of Home Economics*, Vol. 43, p. 2, May 1951.

carry out, and give students an opportunity to see for themselves just how dependent health is on the right selection of food.

Dogs, cats, pigs, and other animals in their growing period show great effects of proper and improper diets. However, the most satisfactory animals for classroom experiments are white rats, guinea pigs, and possibly the chicken.

A. *The Use of the White Rat*

1. White rats are clean, small, and easy to handle.
2. They will eat practically any food given them and require only about 30 grams of natural food a day, or 10 grams of a dried diet.
3. The dietary deficiencies produced are similar to man.
4. Deficiencies are produced quite quickly because growth is rapid.
5. They have a short life span (about 3 years) allowing observations on several generations.

Care of the Rat

Handling

A normal healthy rat is quite friendly, clean, and curious. One need not be afraid to handle the rat, providing it is not treated roughly or that the handler makes no sudden jerks toward or away from it. The rat is a fascinating animal when given its freedom on a table top, but caution is necessary. If the animal gets away from you it may be difficult to catch.

A common practice used in picking the rat up is: place thumb and forefinger behind forelegs and under the jaw, taking care not to grasp too tightly; the remaining hand and finger are loosely placed around the body for support. The use of gloves is always safer.

When talked to or stroking of the head and back, the rat responds quite favorably.

If a person does happen to be bitten, treat with proper antiseptic (70% alcohol) and consult a physician.

Feeding Rats

1. A good grade of rat pellets, rabbit pellets, or dog pellets available at all times;
   or if natural foods are to be used, each of the following should be included:
2. A fresh supply of milk daily or powdered milk four times per week.
3. Green vegetables twice weekly.

4. Cut carrots, lettuce, cabbage or other greens twice weekly.
5. A source of meat (horse meat, liver, heart, fish) twice weekly.
6. Fresh clean water daily.

Animal Characteristics

Rat (Albino)

Normal Conditions:

1. General liveliness.
2. Good disposition.
3. Clean.
4. Bright pink eyes.
5. Pink nose, ears, feet, and tail.
6. Fur soft, smooth, and clean.

Effects of Thiamine Deficiency in Rat:

1. Weight gain for two or three weeks, followed by a steady decline in weight.
2. Loss of appetite.
3. Nervous, excitable condition.
4. Loss of balance, wobbly gait.

B. *The Use of the Guinea Pig*

1. They are completely harmless.
2. They are clean.
3. Guinea pigs do not synthesize vitamin C in their bodies, and react the same as man when vitamin C is not supplied. They develop scurvy quite rapidly.

Care of the Guinea Pig

Guinea pigs are favorite animals for experimentation because they are small, tame, and easy to control. Unlike other rodents, they do not climb.

Guinea pigs are timid animals and because of this will make desperate attempts to free themselves when held. However, if handled and treated properly they become very friendly in a short time. Although one might get scratched by the guinea pig if it is held improperly, it is very unlikely that it will bite.

Because the guinea pig is unable to synthesize vitamin C, they are used most frequently for vitamin C assays.

Handling

Guinea pigs are probably the easiest of animals to handle.

By placing one hand over the back of the animal, supporting the hind legs with the other hand, the guinea pig may easily

and harmlessly be picked up. If it is necessary for one hand to be free, place hand over back; grasping behind forelegs tilt animal backward so that it is being held in palm of hand.

Feeding Guinea Pigs

1. Guinea pigs must have an abundant supply of some type of greens (cabbage, lettude, hay, oats, clover).
2. A good grade of pellet food (rabbit or guinea pig pellets).
3. Fresh clean water daily.

Animal Characteristics

Guinea Pig (Albino)

Normal Characteristics:

1. Alert.
2. Coat smooth, shiny, unsoiled, and dense; the hair strong but not harsh.
3. There should not be a discharge from mouth or nose.
4. Posture erect with a very stable walk.
5. Growth is rapid for the first two months.

Effects of Vitamin C Deficiency in Guinea Pig:

1. The first symptom is a tenderness of the joints, wrists, ankles, and knees. The animal will squeal when joints are pinched.

2. Gradual swelling of joints.
3. Fragility of bones.
4. Loss of appetite.
5. Decline in body weight after 12th to 15th day on vitamin C deficient diet.

C. *The Use of the Chicken*

1. They are readily available.
2. Young chicks grow rapidly. Because of this rapid growth, the chick is well suited for diets deficient in certain essentials.
3. They are easy to handle and don't bite.
4. They are messy, smelly, and noisy.

Care of the Chicken

Chicks for nutritional work are usually about one week old. They are a good source for experimentation because of their availability and rapid growth. However, the chick is a noisy, dirty, smelly animal as compared to the rat or guinea pig. They are very easy to handle and do not bite.

Feeding Chickens

1. A good source of chick feed, preferably mash type.
2. Supplements of green food (grass, lettuce, cabbage).
3. Fresh clean water daily.

GENERAL PROCEDURES

II. *Materials Needed for Conducting Animal Feeding Experiments*

A. At least four animals, two in each group. They may be all males, all females or one female and one male per group (males grow more rapidly than do females).
B. Food and water containers, one of each per cage. Empty cold cream jars (5 oz.). A special water bottle may be made with a test tube, a one-hole rubber stopper with bent glass tubing.
C. Newspapers.
D. Diet. Enough food to last through duration of experiment.
E. Gram scales preferable.
F. Two cages (one for each group of two animals).

Construction of Cage:

1. Galvanized hardware cloth $\frac{1}{8}''$ mesh.
2. Wire cutters.
3. Flexible wire for fastening.
4. Pliers for bending wire.

5. Ruler and crayon to mark for cutting.
6. Four shallow cake pans, 9″ circular or 10″×10″ square cake pan or rectangular pan, depending on whether a circular or square cage is used.
7. Two weights, such as bricks or rocks, to hold cage covers in place.

Cages should be large enough to contain a minimum of two rats, as each experimental group would necessitate at least two or more rats.

A circular cage 9″ high and 9″ diameter, or a rectangular cage 8″×8″×10″ would be very suitable.

To Construct a Circular Cage

1. 2 pieces of ($\frac{3}{8}$″ mesh) hardware cloth.
   a) 1 piece 12″×12″
   b) 1 piece 32″×9″
2. Two shallow cake pans 9″ diameter with 2″ sides.
3. Using wax paper, cut a circular pattern 10″ in diameter. From this draw a circle on the 12″×12″ wire. With wire cutters, cut around this circle. To be used for bottom of cage.
4. Cut about 1″ inward, at about 1″ intervals. Bend tabs at right angles. Use as elevated platform.

For sides:

5. Roll 32″×9″ wire together so that this will fit into cake pan. Lace together with flexible wire. Upon the completion of lacing, remove excess wire.
6. Place bottom inside cylinder so that tabs project downward about one inch.
7. Line the bottom of cake pan with newspapers.
8. Place into cake pan. Place another cake pan on top, held in place with weights (bricks, stones).

To Construct a Rectangular Cage

1. 2 pieces of ($\frac{3}{8}$″ mesh) hardware cloth
   a) 1 piece 10″×10″
   b) 1 piece 10″×34″

For bottom:

2. From each corner of the 10″×10″ piece cut inward toward the center one inch. Fold each side at right angles. This will be used for one inch elevation of floor.

For sides:

3. With the 10″×34″ cloth make a right angle fold one inch for

end. From this point make three right angle folds eight inches apart. Lace together with flexible wire.

4. Place sides onto bottom with folded edge to the outside, allowing one inch projection to be used for floor elevation. Lace together with flexible wire.
5. Line the pan with newspapers.
6. Place into pan of comparable size (square, rectangular, or circular). Place another pan on top, held in place with weights (bricks, stones, etc.).

Wire to each cage an identification tag containing age, weight, name or number of each rat, sex, and diet.

Change newspapers daily. Wash cages with mild disinfectant (soap and water) weekly. Be certain cages are dry before rats are returned to their proper cage.

Cages should be located away from drafts, direct sunlight, and constant disturbance. Place them where they can be observed but not where they will draw attention.

When removing rats from cage, be sure they are returned to the proper cage. Remove only one rat at a time.

Cages for Guinea Pigs

Cages should be large enough to house a minimum of two guinea pigs.

A rectangular cage construction using hardware cloth of $\frac{1}{2}''$ mesh $15'' \times 12'' \times 12''$ would be large enough for two guinea pigs.

These cages could be constructed in the same manner as the rat cages, using the dimensions above.

The food and water containers are best wired to the inside of the cage slightly above the floor to prevent the animal from sitting inside them.

The newpapers lining the pan below cages must be changed daily.

Guinea pigs are not as hardy and resistant to disease as rats and may die from colds or other infections. The cages therefore should not be placed in drafts or where sudden temperature changes occur, nor should the guinea pigs be exposed to direct sunlight.

Cages for Chicks

As for housing, a circular cage constructed in the same manner as the one for rats, using $\frac{1}{2}''$ mesh or chicken wire, will hold two or three chicks. In place of the newpaper contained in the cake pan below the cage, you could put two inches of sawdust. Water and feed containers large enough to permit all chicks to feed at the same time should be provided. These could be wired to the outside of cage to prevent spilling.

III. *Keeping Records*

In order to keep track of the experiment, to evaluate and compare the results, it is essential that the experimenter maintain a good set of records.

Attach to the side of the cage a 3″×5″ card giving the following information:

1. Diet.
2. Identification of animal (number, color marking, or name).
3. Date experiment began.
4. General remarks (gross symptoms as they occur during experiment, loss of appetite, food consumption, behavior, etc.).
5. Age, sex.

A permanent notebook with the following information should also be kept.

1. Objective of experiment.
2. The diet, with ingredients listed for each group of animals.
3. Characteristics of animal at the beginning of experiment.
4. Record of any deviation from normal characteristics as they occur.
5. Growth as shown by gain in weight.
6. Conclusions.

Marking for Identification

The use of India ink, picric acid, or clothes dye may be placed on the fur in different places (base of tail, neck, under the chin). This would have to be renewed every two or three days. Be sure ink is dry before putting two rats in the same cage. Colored string placed around the ankle of the chick firmly but not too tightly would serve well. For large groups of rats or guinea pigs, a series of holes may be punctured in the ear.

Weighing

A gram balance is most suitable because of slight day to day changes in weight. If such a balance is not available, perhaps the biology, chemistry, or physics department would be willing to lend one to the group.

Animals on nutritionally deficient diets should be weighed three times weekly for the first two to three weeks, then weighed daily.

Place an empty coffee can (or similar can) on left side of scale and balance with small objects (jar cover, pieces of paper, etc.). Place rat in can, then add gram weights to balance. A cover, with holes punched through it, may be placed on top of can to contain animal while weighing.

To avoid mix-ups, only one rat at a time is removed from cage.

Duration of Experiment

The time limit for any one particular experiment will vary greatly with diet and type of animal used. In general, when foods commonly chosen for human consumption are fed to animals, with a great degree of nutritional contrast, two to four weeks are sufficient, especially when using the chick. When vitamin deficient experiments are tried, depending upon the type of vitamin and animal, four to eight weeks are necessary. (Vitamin C, using the guinea pig takes about three weeks.) Supplements to the original diet should be given when the weight remains about the same for two or three successive weighings and/or deficiency characteristics occur.

When the animal becomes depleted, the diet should be supplemented with foods or vitamins so that normal health conditions may be regained.

When the experiment is completed, it is not a good policy to let students take the animals home; dispose of them. This may be done by placing the animal for 15 or 20 minutes in a can containing cotton soaked with chloroform. In reference to the rat, it must be remembered that it is a wild animal. However, the guinea pig makes a good pet.

Part II. Animal Experiments

IV. *Rat Studies on an Elementary Level*

Demonstrations have been carried out to show the effect of various natural foods as a growth factor in rats.

Diet I. Hamburger, milk, cabbage, whole wheat bread, butter
Diet II. Hamburger, whole wheat bread, milk
Diet III. Hamburger, whole wheat bread
Diet IV. Milk
Diet V. Hamburger (first three weeks; fourth week added milk, whole wheat bread)
Diet VI. Milk, whole wheat bread
Diet VII. White bread (first three weeks; fourth week added hamburger and cabbage)
Diet VIII. White bread, butter, sugar (first three weeks; fourth week added milk)
Diet IX. Whole wheat bread (first three weeks; fourth week added hamburger)

As it is necessary to supply a sufficient amount of food for all rats for the duration of the experiments, a quantity of each food item must be purchased. The hamburger is fried into patties of medium size, about 25 grams, and, together with the bread, placed in a freezer and used as needed. They need not be thawed before being placed into the cage. The milk and cabbage may also be purchased in quantity sufficient for several days and placed in a refrigerator and used as needed.

Daily feedings for each diet per group of two rats: 1 hamburger

patty, 1 slice of bread, ½ cup milk, 1 pat of butter spread on bread, constant supply of sugar, constant supply of water.

When feeding this type of diet, it becomes necessary that the animals receive care over the week end. Dry food not eaten should be removed daily and milk changed daily as it might become sour.

A better form of diet might be made up in powder form. This could be done by allowing the bread to dry out, then grind into powder. Powdered skim milk (from most grocery stores) and dried powdered meat (obtainable at a feed store) is then mixed thoroughly with pulverized bread.

Pulverized bread	50%
Powdered skim milk	25%
Dried powdered meat	25%

In using this powdered diet, food cups could be filled to last over Saturday and Sunday.

Results:

As expected, the rats getting most of the essential foodstuffs (carbohydrates, fats, proteins, minerals, vitamins), Diet I—hamburger, milk, whole wheat bread, butter, and cabbage; Diet II—hamburger, milk, and whole wheat bread; Diet III—hamburger and whole wheat bread, had a high rate of weight increase as indicated in Table I and Chart I. (The greatest gain is noted in the order of Diets I, II, III, etc.) The rats receiving only one or two good food sources (Diet IV—milk, Diet V—hamburger, and Diet VI—milk and whole wheat bread) had only a fair rate of weight increase. The rats receiving milk only developed diarrhea and anemia. Blood samples from rats on milk (Diet IV) showed one rat with 6.4 grams hemoglobin per 100 grams of blood; the other rat of that group had 5.1 grams hemoglobin per 100 grams of blood. Blood samples from rats on hamburger, milk, and whole wheat bread (Diet II) showed one rat to have 12.3 grams of hemoglobin per 100 grams of blood and the other rat to have 12.3 grams of hemoglobin per 100 grams of blood, which is normal for young rats. This test was determined by measurement of acid hematin with Klett reference standard on a Klett-Summerson Photoelectric Colorimeter. Rats on white bread (Diet VII); white bread, butter, and sugar (Diet VIII); and whole wheat bread (Diet IX) showed a very poor rate of weight increase, although they looked healthy in other respects (eyes, hair, gait, etc.). The weight differences of rats on whole wheat bread (Diet IX) as compared to white bread (Diet VIII) were very slight, indicating that the nutritional value of whole whest bread used in this experiment may not be any better than that of the white bread used. When Diets V, VII, VIII and IX were supplemented, i.e. hamburger with milk and whole

wheat bread; white bread with hamburger and cabbage; white bread, butter, and sugar with milk; and whole wheat bread with hamburger, there was a rapid weight increase, indicating that more than one type of food is essential for normal body growth. For weight gains of rats used in these experiments, consult Table I and Chart I.

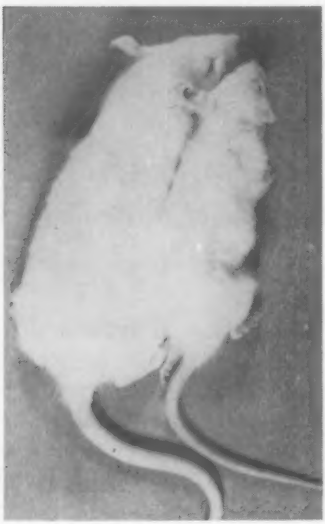


FIG. I

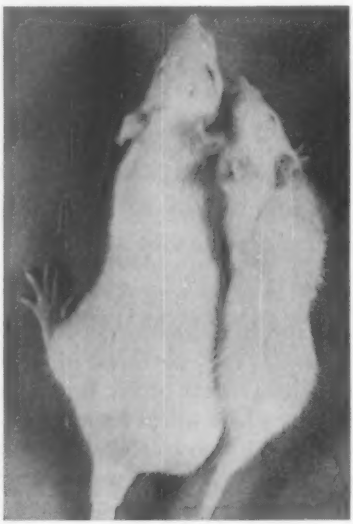


FIG. II

FIG. I. The rat on the left received a diet of hamburger, milk, and whole wheat bread. The rat on the right received hamburger only.

FIG. II. The rat on the left received hamburger, milk, and whole wheat bread. The rat on the right received whole wheat bread.

Conclusion:

Experiments with growing rats using foods commonly consumed by man clearly demonstrate that growing boys and girls need a well balanced diet to be healthy. While a certain type of food may be a good source of certain essentials (fats, carbohydrates, protein, vitamins, minerals), no one food will supply all the necessary essentials. For further information concerning the carbohydrate, protein, fat, and vitamin values of the foods used in these experiments, as well as other foods that might be used, consult Table II.

V. *Experiments for More Advanced Groups*

A. *Rats on Thiamine Deficient Diet*

To determine the growth factor of vitamin B_1 on female rats. One

group (2 rats) on a complete diet, the other group (2 rats) on a B_1 deficient diet.

Complete Diet[2]

	%
Casein	25
Sucrose	61.7
Crude Soybean Oil	3
Cod Liver Oil	2
Methionine	0.3
Salt (N.B.C. "W")	4
Vitamin Supplement in Starch	4

Vitamin Supplement per 100 Gm. of Diet

i-Inositol	100 mg.	10 g.
Choline Chloride	30 mg.	3 g.
Menadione Cryst. (Vitamin K)	200 μg. (in C.L.O.)	20 mg.
Mixed Tocopherols (Vitamin E)	20 mg. (to S.B.O.)	2 g.
B_1	2 mg.	0.2 g.
B_2	2 mg.	0.2 g.
B_6	1 mg.	0.1 g.
Ca Pan	6 mg.	0.6 g.
Nicotinamide	10 mg.	1.0 g.
Biotin	10 μg.	1000 μg.
Folic Acid	50 μg.	5000 μg.
B_{12}	1 μg.	100 μg.

Deficient Diet:

Same as above excluding vitamin B_1.

Each of these diets (complete and deficient) being in powder form does not create any week end feeding problems. With powdered diets, the food jars and water jars may be filled to hold a sufficient amount to last through Saturday and Sunday.

Results:

The rats on the complete diet showed a steady weight increase. Beginning with a weight of 52 grams, they reached a final weight at the end of three weeks of 160 grams, which is a normal three weeks' growth for rats. The rats on a vitamin B_1 deficient diet had a weight increase up to the fourth day (although not as rapid as rats on complete diet). From the 4th day to the 12th day the weight increase was very slow, showing a tendency to level off, which it did from the 12th to the 15th day. From the 3rd to the 16th day, there was a noticeable loss of appetite. On the 15th day, each rat received 10 μg. per day of vitamin B_1 in 1 ml. of 15% alcohol, with a little sugar added to incite a taste. At this point there was a sudden and rapid weight increase. In one week's time, the weight of these rats nearly approached the

[2]Source of diet: H. G. Petering, The Upjohn Company, Kalamazoo, Michigan.

control group. There was also an increase in appetite. For weight gain results consult Chart II.

FIG. III. The rat on the right is a normal healthy rat while the rat on the left is deficient in vitamin B_1.

Conclusions:

The duration of the experiment should be three weeks for good results. In this length of time, the control rats show a good weight increase, while the test group show a plateau in weight at about 2 weeks, at which time a supplement of vitamin B_1 is added as follows: (two dilutions) Dilution I, 0.1 gram of B_1 to 100 ml. of 15% alcohol; Dilution II, 1 ml. of Dilution I to 100 ml. of 15% alcohol. One ml. (plus a small amount of sugar) of Dilution II is fed to each rat daily. In one week the rats receiving vitamin B_1 supplement show a rapid increase in weight.

It might well be pointed out here that vitamin B_1 deficiency results in a disease in man called beriberi. "In the United States, classical beriberi is rarely seen."[3] This is probably due to the fact that so many of the foods (bread, cereal products, flour, etc.) are enriched, which gives us a greater assurance that a sufficient amount of vitamin B_1 is being supplied.

The vitamin B_1 deficient and complete diet can be obtained from

[3] F. A. Robinson, *The Vitamin B Complex*, John Wiley and Sons Inc., New York, 1951.

the General Biological Supply House, Chicago 20, Illinois, or Nutritional Biochemical Corporation, Cleveland 28, Ohio.

Table I

Comparison of Rat Growth on Common Foods

Diet*	Beginning Weight	Final Weight		Weight Gained Weekly			Total Gain	
		1st 3 Weeks	4th Week	1	2	3	3 Weeks	4th Week
1. Hamburger,† whole wheat bread, milk, butter, cabbage	48	168		22	53	45	120	
2. Hamburger,† milk, whole wheat bread	48	140	—	15	35	42	92	—
3. Hamburger,† whole wheat bread	44	112	—	8	36	24	68	—
4. Milk	45	100	—	4	22	28	54	—
5. Hamburger†	45	99	120	8	24	22	54	21
6. Milk, whole wheat bread	48	115	—	7	18	26	51	—
7. White bread	42	62	78	1	8	6	15	21
8. White bread, butter, sugar	45	52	68	4	1	2	16	16
9. Whole wheat bread	45	53	62	3	5	0	8	9

* Following the third week, rats on the following diets received supplements.

Diet:
No. V Milk and whole wheat bread
No. VII Hamburger and cabbage
No. VIII Milk
No. IX Hamburger

† Hamburger in all cases was cooked.

Table II

Possible Food Table for Experiments

Constituents of 100 Grams

Foods	Portion		Foodstuffs			Vitamins			
Name	Weight in Grams	Measure	Carbohydrate	Protein	Fat	A	B_1	Riboflavin	C
			g.	g.	g.	I.U.	mg.	mg.	mg.
Baked Goods									
Cake	30	1 slice	57.0	6.4	8.2	0	.03	.10	0
Cookies	23	1 cookie	75.0	6.0	12.7	0	.04	.04	0
White bread enriched	23	1 slice	52.3	8.5	2.0	0	.24	.15	0
Whole wheat bread	28	1 slice	48.0	9.5	3.5	0	.28	.15	0
Dairy Products									
Butter	15	1 tbsp.	.4	.6	81.0	3,300	Trace	.01	0
Milk									
fresh whole	240	1 cup	4.9	3.5	3.9	160	.04	.17	1
dry skim	10	1 tbsp.	52.0	35.6	1.0	40	.35	1.96	7
Fruits and Fruit Juices									
Apples	127	1 medium	14.9	.3	.4	90	.04	.02	5
Banana	100	1 medium	23.0	1.2	.2	430	.09	.06	10
Orange	136	1 medium	11.2	.9	.2	190	.08	.03	49
juice (Canned)	113	4 oz.	10.9	.8	.2	160	.074	.02	37
Cereal Products									
Corn flakes	21	1 cup	80.3	7.9	.7	0	.16	.08	0
Oatmeal (cooked)	136	½ cup	68.2	14.2	7.4	0	.35	.14	0
Meat Products									
Hamburger (cooked)	88	1 cake	0	16.0	28.0	0	.10	.13	0
Heart (beef, cooked)	75	2 slices	.7	16.5	6.3	0	.34	.90	14
Liver (beef, fried)	136	1 piece	3.6	19.8	4.2	19,200	.27	2.80	31
Sugar and Sweets									
Candy	60	5 pieces	66.97	5.0	21.1	0	.08	.12	0
Sugar (granulated)	13	1 tbsp.	99.5	0	0	0	0	0	0
Vegetables									
Cabbage	43	1 cup	5.3	1.4	.2	80	.07	.06	52
Carrot (fresh)	66	½ cup	9.3	1.2	.3	12,000	.07	.06	6
Lettuce (head)	57	3 large leaves	2.9	1.2	.2	540	.06	.07	8

Although most people do not weigh their food, weighing is good experience for upper grades.
All weights taken from *Nutritional Data*, H. J. Heinz Company, Pittsubrgh, Pennsylvania, 1950.

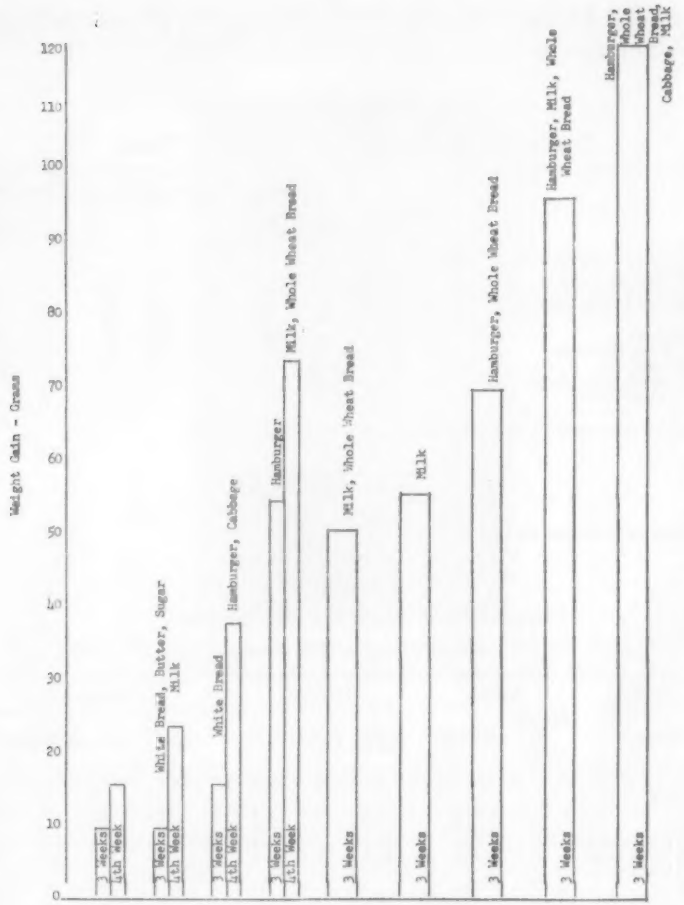


CHART I. Weight gain of rats on various diets.

Pamphlets giving procedures for setting up nutrition experiments. Available to anyone

1. *Laboratory Experiments in Nutrition*, General Biological Supply House Inc., Chicago, Illinois. A pamphlet devised to help the teacher establish animal experiments in the classroom, with emphasis on the white rat. Actual experiments concerning all foodstuffs are included (proteins, fats, carbohydrates, minerals, and vitamins). Vitamin diets (complete and deficient) can be obtained from the Biological Supply House.
2. *Animal Feeding Demonstrations for the Classroom*, Evaporated Milk Association, Chicago 1, Illinois. A pamphlet designed to help the elementary teacher establish rat and chick feeding experiments, using natural foods. A list of good and poor diets for boys and girls is given, along with a food table which might be used in developing a diet more closely fitted to a given community.
3. *Nutrition Experiments with Chicks*, Carey D. Miller, University of Hawaii,

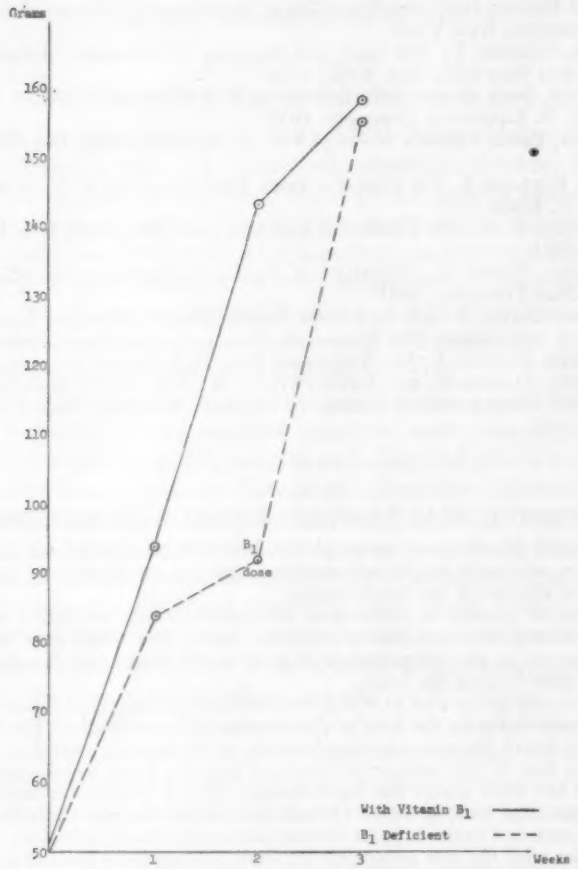


CHART II. Vitamin B_1 assay.

Honolulu, 1940. A two-week demonstration to show school children the effects of good and poor diet using human foods.

4. *Chick Growth Teaches Nutrition*, Martha Potgieter, University of Connecticut, Storrs, Connecticut. A short term (5-day) demonstration to show the value of an adequate diet using human foods.
5. *Nutrition Experiments with White Rats*, E. Neige Todhunter, University of Alabama, University, Alabama. Ideas to show school children how to set up experiments using human foods.
6. *How to Conduct a Rat-Feeding Experiment*, Wheat Flour Institute, Chicago, Illinois. A pamphlet that will help the teacher establish a rat feeding experiment at different grade levels. Actual experiments point out the value of two good food sources as compared to only one good food source.

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UNSUSPECTED HEART DISEASE FOUND WITH RADIOIODINE

Unsuspected heart disease or suspicious heart disease symptoms may be detected by a relatively simple radioactive technique for measuring the flow of blood in the arteries of the heart muscle.

A very small amount of radioiodine compounds is injected into a vein. Two scintillation counters, one placed over the heart, the other over the brain, follow progress of the compound as it goes to the heart and thence into the arterial system feeding the brain.

The difference in the rate at which the radioactive compound clears the heart and the brain is due to the flow of the compound into the heart blood vessels. In coronary heart disease some blood vessels of the heart are blocked.

Thus the flow of the radioactive material into the heart blood vessels is impeded and the more severe the heart disease the less radioactive material that can flow into the heart arteries. In fact the rate of clearance of radioactivity from the heart and brain in heart disease patients is almost identical.

In studies with the new procedure the investigators have been able to detect heart disease in subjects with normal appearing electrocardiograms. In other cases it has helped to confirm other findings symptomatic of heart disease.

ANTIMALARIAL DRUG FOUND TO BE A GOOD LOCAL ANESTHETIC

A drug used successfully in treating malaria and chronic arthritis has now been found to be a good local anesthetic as well.

In speed of action and effectiveness it compares favorably with both novocaine and xylocaine, although it is chemically unrelated to thse common anesthetics.

In a group of 31 unselected patients, the drug produced in all cases prompt effective local anesthesia that proved adequate for the performance of skin surgery.

No systemic or local toxicity has been observed. A disadvantage, however, is the fact that the drug causes prolonged bleeding at the sites of scalpel surgery. This anticoagulant property was unaltered by the presence of epinephrine.

Bohr's Model of an Atom

David E. Laird

Washington Township Schools, Centerville, Ohio

The last few years have seen an ever-increasing number of schools adding advanced work for additional courses in science. Many of these added courses have offered work in the field of radioactivity. High schools rarely offer quantitative study based on the extra-nuclear structure of the atom. This is perhaps unfortunate since much work has probably already been done in physics on static electricity and light. The following paper will sketch some of the class activities which have been designed to reveal some of the things that are known about the behavior of electrons and atoms.

To many the word "model" calls up visions of a science fair with models of power plants, nuclear reactors, and even atoms, with colored lights sweeping out circular and elliptical orbits around the nucleus. But here I wish to discuss an altogether different type of model: one which occurs only in the brain. In 1913, Niels Bohr in Denmark used the word "model" in his paper on the hydrogen atom in a new and different way. In an attempt to show how the hydrogen atom produces the observed spectrum lines, Bohr used a series of mathematical equations; the equations, rather than circling lights, were the parts of the model. Even though a model airplane is supposed to look like a real airplane, no one would confuse the model with the real airplane. Unfortunately there are many who confuse Bohr's model of the hydrogen atom with the real thing. Although the model does attempt to predict the way in which hydrogen atoms will behave, it does not claim at all to represent how a hydrogen atom looks.

To begin, let us observe the way in which hydrogen atoms behave. For about three or four dollars a hydrogen spectrum tube may be obtained. If we put our hydrogen tube on the business end of a few thousand volts at low current, it glows with reddish light. A suitable high voltage source might be a simple spark coil or neon sign transformer. The current through the tube should be limited to about twenty milliamperes. If we now look at the tube through a piece of inexpensive diffraction grating (available at low cost from Edmund Scientific Company, Great Barrington, New Jersey) we see part of the celebrated Balmer series of spectrum lines: a red one, then blue-green, then perhaps one or two in the violet although these are hard to distinguish.

After the establishment of accurate spectroscopy, physicists were challenged to explain the positions of the observed spectrum lines. The first step forward was taken in 1885 by Balmer, a Swiss school

teacher. By empirical, or cut-and-try, methods Balmer succeeded in writing a formula to describe the positions of these lines:

$$\frac{1}{L}=R_H\left(\frac{1}{2^2}-\frac{1}{n^2}\right).$$

By using this formula we can calculate the wave length, L, of any spectrum line in the Balmer series in centimeters. R_H, the Rydberg constant, was calculated by Balmer from the known position of the lines to be 109,678. This number seemed quite mysterious to scientists of the time who had no theory which would in any way explain why the constant should have just this magnitude.

To use this equation, different values are substituted for n. When the number three is used the wave length may be calculated to be 3.645×10^{-5} cm. or 3645 Angstrom units. When four is used for n, the blue-green line at 4861 Angstroms is obtained. Using the value five, a blue line at 4340 Angstroms is obtained. Higher values for n give wave lengths in the violet and ultra-violet which cannot be seen. Fortunately, the next few lines do not go very far into the UV and can be photographed easily. Any camera may be used but the Polaroid Land camera is especially convenient for use in class. To make the exposure, the spectrum tube may be set up vertically and the camera placed at the nearest distance at which it will focus on the spectrum tube. A piece of diffraction grating large enough to cover the lens is mounted directly in front of the lens. It is necessary that the lines on the grating be parallel with the spectrum tube; this may be done by first sighting through the grating at the tube and rotating the grating until the spectrum lines are observed to be parallel to the spectrum tube. It may not be necessary to use a slit in front of the spectrum tube, since most tubes are quite narrow in the center and act as a line source.

Examination of the finished photograph should reveal several closely-spaced lines which were invisible to the unaided eye. The red line will probably be quite faint and the blue-green line will be most intense. There will be considerable space between the red line and the blue-green and there may be some fainter lines in this region. These are probably part of the molecular spectrum of hydrogen. The electrical discharge breaks up most of the molecules so that the strongest lines are those of atomic hydrogen. The blue-green line is then followed by some more faint molecular lines, then the blue and violet lines appear, closer together. Finally, many closely-spaced lines may be seen beyond these. I have located at least seven lines by this method and careful work might bring out one or two more.

We have just constructed a simple spectrograph. Before it can be used to check the results of Balmer's mysterious equation, it must be

calibrated. To do this we may use the well-known grating equation which has probably been previously developed in the physics course. The wave length is given by $L = d$ sine angle, where d is the grating space. Generally the manufacturer will provide information about the number of lines per inch on the grating. Commonly, this will run to 12,000 or 15,000 lines per inch. From this d should be calculated in centimeters. Now what is the angle in this equation? The photograph of the spectrum will show the different spectrum lines appearing to the right or left of the spectrum tube. If we imagine ourselves to be inside the camera, then the spectrum lines will appear to us at some angle as measured from the line connecting the camera and the spectrum tube. To facilitate measurement of the angle, it will be convenient to lay off a measured base line between the camera and the spectrum tube. Now a meter stick may be supported horizontally and directly behind the spectrum tube so that it is exactly perpendicular to this base line. Examination of a photograph made under these conditions will show the spectrum lines superimposed on the meter stick. A magnifier will aid in reading the apparent distance of any spectrum line from the spectrum tube. If we now divide the distance of the spectrum line from the tube by the length of the base line, we now obtain the tangent of the angle of deviation of the spectrum line. This value of the tangent may be located in a table of trigonometric functions and the value of the corresponding sine may be taken directly from the table and substituted in the grating equation.

The typical student in an advanced physics course will be fascinated by being able to photograph and measure something he has "predicted" from a theory, expecially when it is something he cannot even see. This, of course, is the heart of the method of modern physics. At this point, someone may ask, we hope, why the Balmer formula works. What is it all about? This brings us directly back to Bohr's model.

It is not the purpose of this paper to discuss Bohr's concept of the hydrogen atom in full technical detail since most introductory texts on atomic physics cover this topic adequately. A simplified presentation of the mathematics necessary for constructing Bohr's mathematical model will be found in *Foundations of Modern Physical Science* by Holton and Roller, Addison-Wesley, 1958. In brief, Bohr attempted to explain the observed hydrogen lines in terms of orbiting electrons. In Bohr's view the electron of hydrogen might orbit about the lone proton of the nucleus on one of a number of fixed, circular orbits. When an electron "jumps" from one of the outer orbits to the next inner orbit, it liberates one quantum of energy. The energy of this quantum, which may be calculated from Bohr's simple theory, determines the wave length and color of the observed spectrum lines. Thus

the concentric "orbits" represent the possible energies which the electron may have. When the electron has absorbed energy, say from a high voltage electrical discharge through the gas, it jumps out to a larger orbit (higher energy level) for awhile, then it falls back to a lower energy level and gives off a photon which can then be seen or photographed. Bohr's major contribution was in showing that only certain definite energy levels are possible; hence, the spectrum shows lines: it is not continuous as is the spectrum from a glowing filament.

Thus Bohr's theory was found to be capable of predicting quite exactly the spectrum lines which are observed for hydrogen. Now what is remarkable about this? Bohr was able to explain the mysterious Balmer formula! He was able to show that the Balmer formula may be obtained by making certain assumptions about the behavior of electrons. The fabric of Bohr's theory is woven from the basic properties of electrons—their mass and charge—the velocity of light, and Planck's constant. The mysterious Rydberg constant turns out to be a combination of these properties.

Once we have worked out Bohr's mathematical theory, we discover that we are in possession of an extremely attractive and satisfying picture of the behavior of the electron in the hydrogen atom. We can visualize it jumping from one circular orbit to the next, absorbing or liberating energy as it jumps. This view is subject to only one criticism. Subsequent theoretical investigations of the nature of the electron have shown that there is no possibility that this clear-cut picture of the orbiting electrons is true. We find that our mental picture of the jumping electron is far too naive. Bohr himself was aware that his model of the hydrogen atom was not subject to visualization. The actions of electrons simply cannot be imagined and we only delude ourselves if we attempt to do so. We must remember that the "orbits" and "jumps" in the Bohr atom are words which we use to describe Bohr's equations and that they do not apply in the usual sense to the activities of electrons.

We see that Bohr's atom model cannot tell us what an electron looks like nor even what it does. What good is the model? It is only useful for predicting what we may observe as the result of the electron's activities. The model is not a physical thing and cannot be visualized. It is a set of mathematical conceptions in the brain. It cannot be fashioned of string and sealing-wax.

In conclusion, I should like to recommend this type of model building. The students who can be motivated to construct this model for themselves from the algebra which they already know will be able to use it to make predictions which can then be checked by experiment.

The Science Program in the Province of Manitoba*

Willlam H. Lucow

Faculty of Education, University of Manitoba, Manitoba, Canada

The Impetus Behind a Science Program

A science program includes all the administrative arrangements, curricula, and activities involving the schools in the effort to imbue children with scientific knowledge, method, and attitudes necessary to meet the array of objectives usually associated with a course in science.

Since the early days of science instruction, programs and arrangements have been given origin and direction by three fairly discernible forces. At first, guided by serial and saltatory theories of learning, traditional programs stressed nature study, emphasizing observation, collection, and memorization of names (1). Then, in the 1930's, progressive education emerged with the acceptance of the principle of maximum development of individual differences and the recognition that mental traits develop gradually and together. Science programs stressed continuity and correlation with other subjects, with particular emphasis on the relation of science to everyday life. The third and most recent force has been the genesis of the atomic, missile, or space age. The country's need for specialists in science and for very many science-oriented above-average individuals has put a new impetus behind science programs.

The aim to produce as many science sophisticates as the normal distribution of brains will allow is being pursued in a variety of ways. The fact that one program differs from another need not prevent the harvesting of equivalent crops of scientists. Programs differ with success; but ambiguity, vacillation, or ignorance may make one unsuccessful. It might be well to know the nature and location of one's science program.

Science Programs Operate Along a Continuum

Science programs operate along a continuum that extends from *laissez-faire* at the extreme left to total *prescription* at the right.

By laissez-faire is meant: (a) complete freedom on the part of the teacher to select science topics for instruction; (b) free use of methods arising out of training of the individual instructor; (c) examinations constructed and administered by the instructor; and (d) evaluation, recording, and reporting done by the instructor.

By prescription is meant complete outside control of curriculum,

* Paper presented at a meeting of Section Q, American Association for the Advancement of Science Convention, Chicago, December 30, 1959.

text books, required experimental work, and method and timing of of instruction—followed by an examination set and marked by the outside authority.

Science programs exist somewhere between the two extremes on this continuum.

This paper attempts to locate the science program of the Province of Manitoba along the continuum. It will be seen that the programs for elementary, junior high, and senior high levels differ in treatment, so their locations will be suggested separately. Figures are then presented to raise the question whether the crop of high school graduates pursuing science courses at university includes as many as might reasonably be expected.

Public Education in Manitoba

The ten provinces of Canada are political divisions that correspond roughly to states in the U.S.A. School curricula and all matters pertaining to education within a province are the exclusive concern and responsibility of that province. Thus, at least ten different science programs exist across the Dominion. The science program under discussion is that of the Keystone Province, the Gateway to the West—the Province of Manitoba.

This is the story of science instruction in the schools serving a population of nearly one million people spread over an area just a little smaller than Texas. The capital city is scenic, electrical, modern Winnipeg, just over an hour's drive along the splendid highway from the border town of Noyes, Minnesota. In the heart of Winnipeg, facing Memorial Boulevard, is the Legislative Building of the Province of Manitoba. Most of the main floor on the west side is occupied by the Department of Education. It is this Department that directs and administers all courses of instruction in the Province, including the science program.

The Science Program in the Elementary School

The science program in the elementary school is located far to the left, or laissez-faire end of the continuum. While an outline of content in nature study is provided, no specific text is prescribed; the teacher is free to do little or much in the subject; and no outside-the-classroom check is made of achievement by way of formal examination.

The outline issued by the Department of Education is built on a spiral principle. Thus, the program in the primary division (grades one, two, and three) is repeated in the junior division (grades four, five, and six) with increased scope and detail. Often, because of the teacher's freedom of inclusion or exclusion of topics, many gaps occur

in the spiral. As one principal put it recently, "They get nothing but birds in grade one, more birds in grade two, birds again in grade three, and so on to grade six. I tell you, the program is for the birds!"

As published by the Department of Education, the science program in the elementary school suggests units of study on: birds, trees and shrubs, wild and garden flowers, common weeds, wild and domestic animals, insects, "other" animals (frog, toad, snake, fish, spider, earthworm, turtle, clam, and snail), useful plants, the sky, and weather.

Blueprint for reform.—About twelve years ago, a survey team headed by Dr. William C. Reavis directed a study (2) on the status of education in the City of Winnipeg. The part of the report dealing with nature study and science showed that over half the elementary teachers desired further training in the teaching of science. About two-thirds of the teachers provided for nature study in their timetables; the rest claimed it was correlated with other subjects, particularly art, social studies, language, and literature. The survey showed that about 13% of the teachers gave examinations in nature study, and even fewer gave credit for notebooks. The majority did not report to parents on nature study.

Recommendations of the survey team included: that in-service education on methods of teaching science be given in school hours; that the material in nature study and science be presented as problems to which the pupils are guided in finding the answers from library and experiment; and that the program in the elementary grades be co-ordinated with the courses in junior high and senior high schools.

Following the publication of the report of the *Survey*, one of the general recommendations was implemented: an elementary council was set up. A science committee studied the feasibility of altering the program to include the physical sciences as well as nature study.

An experimental program.—In September, 1959, with permission of the Department of Education, a new elementary course was organized under three main headings, Living Things, Earth and the Universe, Energy and Machines—a program that would articulate with the junior and senior high. An outline bulletin on Elementary Science, borrowed from the Province of Alberta, was issued. The program emphasized science concepts to be taught at each grade level, and suggested methods of developing these concepts.

The content and organization of a new course in elementary science does not, however, move the program from its position on the laissez-faire to prescribed continuum. The teachers of Manitoba are still free to select what they will or will not cover; they might use any of a number of textbooks or none at all; and they are free to do

what they will about evaluation and reporting to parents. The program remains far to the left on the continuum.

The Junior High Program

The science program in the junior high school moves to a central position along the continuum. Textbooks (3) are specified in grades seven, eight, and nine, and an outline issued by the Department of Education lists the required and optional topics to be studied. The outline suggests the following basic principles in teaching general science.

1. Seasonal arrangement of topics
2. Content and activities related to experience
3. Direct experience rather than verbalism
4. Observation and discovery
5. Correlation with other subject areas
6. Exploration of interests
7. Use of visual aids

Evaluation is made of achievement, but this is done by the teacher for his own class. Science is listed in reports regularly sent to parents.

Grade VII.—The grade seven science course covers plants and seeds, insects, foods from plants, properties of air, soils, rocks, minerals, and a study of water.

Grade VIII.—The grade eight course starts with the origin of the earth, and goes on to a rather detailed coverage of geology. This is followed by the only serious presentation of astronomy in the entire public school science program. Winter studies include: drinking water, physical properties of water, and the atmosphere. Spring studies include: erosion by water, snow, ice, plants, animals, winds, and weather. The course concludes with a topic on safety.

Grade IX.—In grade nine all pupils take the course in biology: families of plants, algae, fungi, bacteria, fermentation and decay, fossils, rodents, carnivores, grazing and browsing animals, sea mammals, vertebrates, living cells and life processes, the control and improvement of animals and plants, and a unit on conservation.

Where is the junior high science program along the continuum? Because of the prescribed text and outline, it may be located about mid-way between the two extremes. In the City of Winnipeg, all junior high pupils write the same mid-term examination in science, and the program may be considered a bit to the right of centre.

The Schools Science Centre

Mr. C. A. E. Hensley, M.A., one of the authors of the prescribed junior high science texts, is the director of the Schools Science

Centre, located in Winnipeg. On its letterhead appears one objective: The Improvement of Science Teaching. Activities are as follows:

1. Assisting teachers new to science teaching to make a beginning in the teaching of science centered around specimens, experiments, and learning-by-doing.

2. Assisting in schools where science work at the junior and senior high levels has not been taught previously (such as emergency requisitions for supplies and exchange of supplies between schools).

3. Outdoor excursions with teacher and class: (a) in the school grounds and neighborhood (quick methods of preserving plant and animal specimens); (b) to Bird's Hill (about 15 miles from Winnipeg) for plants, water life, geology; to Sandilands, for general outdoor education and conservation; to Lake Manitoba for rocks and minerals; to the zoo to study how vertebrates adapt to environment; to the water works; and to industrial plants.

4. Maintenance of book display. New texts and reference books for teachers to examine when deciding on library lists. Also lists of sources from which information may be obtained.

5. Testing microscopes and other equipment submitted by dealers and making recommendations to the purchasing agent.

6. Visiting schools at the request of the principal to talk with the staff about getting the science program under way. Books, specimens, and apparatus are shown to the teachers.

7. Holding meetings of teachers (usually the staff of one school) at the *Centre* for inspiration and information.

8. Visiting schools to observe progress in regular work or special project.

9. Organization of science clubs: preparation of plans, suggestions, lists of projects.

10. Conducting the Provincial Science Fair held at the Manitoba teachers' convention during Easter week each year. Much guidance is needed in all club work, with new clubs and teachers not experienced in club work, to keep projects in fields and at grade levels where success is possible.

11. Chairing the examination committee preparing mid-term tests for junior high. The project was set up to improve science examinations in the direction of testing of abilities other than reproduction of facts from the text.

12. Writing a weekly newsletter aimed at improving science teaching through inducing teachers to read the professional journals (such as, *The Science Teacher*, *Science Education*, and SCHOOL SCIENCE AND MATHEMATICS); through keeping teachers reminded of seasonal devel-

opments for nature science; through briefly reviewing books and magazines that should be in the classroom for student use; and through suggesting new and improved methods.

13. Maintenance of a collection of mounted birds and animals that are loaned to schools on a library basis for periods of two weeks and more.

14. Collection of surplus science equipment from schools where courses have changed; adjustment and minor repairs to same, and redistribution where needed.

15. Answering a multitude of questions by telephone and by mail from teachers and from students.

16. Speaking at local conventions of teachers to discuss the activities of the Science Centre.

The ancillary service to science teaching embodied in the Science Centre is a Winnipeg School Division project, but its effects are felt all over the province. Hardly an issue of the *Manitoba School Journal* goes by without an article about the activities of the Centre, and about the services that are available to any science teacher in Manitoba.

The Senior High Science Program

In contrast to the elementary and junior high, the senior high program takes a long step to the right—almost to the completely-prescribed end of the continuum. Here, the text books in general science, biology, physics, and chemistry are prescribed, the topics and pages in the text are specified, required experimental work is designated, and at the end of the school year examinations are administered under the direction of the High School Examination Board of the Department of Education (4).

Grade X general science.—Virtually all pupils in the tenth grade take general science. This is a transition grade as far as complete control is concerned. Achievement in the course is determined by the individual high school, although special examinations may be held by the Department through its inspectors.

The current text is Beauchamp, Mayfield, and West, *Everyday Problems in Science*, in which about half the units are prescribed. These include: how scientists work, composition of matter, changing matter, fire, heat, water supply, simple machines, energy of nature, electric currents, communication, transportation, and conservation. About forty selected practical experiments are prescribed, of which twelve are "to be done by the student where possible." Whether done by the student or demonstrated by the teacher, these twelve must be formally recorded in a laboratory note book available at all times for examination by the school inspector.

Grade XI.—The eleventh grade constitutes junior matriculation year. That is, upon attainment of clear standing, the student is eligible for admission to the University of Manitoba.

The science courses offered in grade eleven are chemistry, physics, and biology. One is compulsory, two are often selected, and all three may be taken under special circumstances (such as in classes for the very bright).

Grade XI chemistry.—The text is Dull, Brooks, and Metcalfe, *Modern Chemistry*, supplemented by a laboratory manual prepared by a Manitoba teacher, Mr. Frank Harder. The course consists of units on: chemistry in a modern world; oxygen and hydrogen; solutions and crystallization; atoms, molecules, valence, equations, formulas, and problems; carbon and its oxides; acids, bases, and salts; compounds of nitrogen; sulfur and its compounds; and chlorine and hydrochloric acid. The student must participate in at least ten experiments, and these must be described in an approved form in a laboratory note book, available at all times for examination by the inspector. At the end of the course the principal or science master must certify the authenticity of each laboratory note book. Chemistry is the most popular course in the eleventh grade sciences. In 1958, 5837 students or 87.5% of the 6670 high school population in grade eleven took the course.

Grade XI physics.—The text is Dull, Metcalfe, and Brooks, *Modern Physics*, supplemented by Dull's laboratory manual, Series I. The course consists of five units: matter and energy, mechanics of liquids and gases, heat, sound, and electricity. Ten laboratory experiments are required, of which five are compulsory: Archimedes' principle, specific weight of liquids, Boyle's law, specific heat of a metal, and lines of force around a magnet. The usual requirements about note books apply. In 1958, 3989 or 59.8% of the grade eleven student body took physics.

Grade XI biology.—The text is Kroeber and Wolff, *Adventures with Animals and Plants*, of which five units are covered. These include: nomenclature and classification of plants and animals, living cells, foods from plants, health and disease, and reproduction. Obligatory practical work is sampled from problems in the text. Identification is required of several trees, shrubs, plants, birds, plant diseases, mammals, fishes, and insects. In 1958, 727 or 10.9% of the grade eleven student body took biology.

Grade XII.—On successful completion of the eleventh grade, students may enter university or continue at high school. Those who elect to remain in high school for the twelfth grade get first year university credit in chemistry and physics on successful completion of the laboratory work and clear standing in the Department of Educa-

tion examinations in June. Grade XII biology is not considered the equivalent of the first year course in biology at the university.

The Manitoba Science Program and the Supply of Scientists

If we consider the continuum in science education starting at the left with complete laissez-faire and going to the right in the direction of more and more prescription and control, the elementary science program may be found far to the left, the junior high somewhere in the middle, and the senior high far to the right. The test of this arrangement lies in the answer to the question: Does the science program produce as many future scientists as it might?

The answer may lie in failure rates. If more pupils are attracted to science courses than pass them, might it not be argued that those who survive the rigid examinations constitute most of the science talent? When those who matriculate to the university are further decimated in the science courses, does it not indicate that virtually all who were capable of doing science were identified? Table 1 below gives the examination results in the grade eleven sciences, and Table 2 shows what happened to those who did pass and who went on to science courses at the university.

Table 1

Results of Manitoba High School Science Examinations in Grade XI for the School Year Ending June 30, 1958

Subject	Enrollment*	Passed†	Failed†
Chemistry	5837 (87.5%)	3813 (65.3%)	2024 (34.7%)
Physics	3989 (59.8%)	2597 (65.1%)	1392 (34.9%)
Biology	727 (10.9%)	578 (79.5%)	149 (20.5%)

* Percentages given are of total enrollment (6670).
† Percentages given are of enrollment in each subject.

About half (3290) of those enrolled in Grade XI proceeded to Grade XII, where the failure rates are very similar for the three sciences. Table 2 shows what happened to those who proceeded to university from Grade XI.

Table 2

University of Manitoba First Year Science Examination Results for the Year Ending April, 1959

Subject	Enrollment	Passed	Failed
Zoology	100	81 (81.0%)	19 (19.0%)
Chemistry	749	516 (68.9%)	233 (31.1%)
Physics	553	440 (79.6%)	113 (20.4%)

In view of the need for more science talent, one might speculate on general sources that might be tapped. First, there is the great pool of students who passed in grade eleven science, but who did not do well enough on the other subjects to gain entrance into the university. Second, there are those who did pass the grade eleven examinations, but for one reason or another did not go to the university. Generous scholarships might be the answer for many of these. Third, every school system has its brilliant delinquents. Reclamation of these by early identification and adjustment of environment might add to the supply of scientists. Finally, it might be possible to divert brilliant minds who might otherwise become great poets, writers, clergymen, lawyers, and artists of various kinds. There is a moral responsibility to society here, if not some other fundamental issue.

References

1. NSSE Yearbook, 31st, Part I. *A Program for Teaching Science.* University of Chicago Press, Chicago, 1932.
2. Reavis, Wm. C. et al. *Report of the Directed Self Survey, Winnipeg Public Schools.* Committee on Field Services, Department of Education, University of Chicago, September, 1948.
3. Hensley, Patterson, Armstrong. *Science Indoors and Out.* (Gage, Toronto, 1950. (Books I, II, III.)
4. *Programme of Studies for the Schools of Manitoba, Senior High Schools, 1958–59.* Authorized by the Minister of Education, Province of Manitoba.

LONG-KNOWN PROCESS MAY SUPPLY SPACE TRAVELERS WITH OXYGEN

Future space travelers may get their oxygen from a chemical process known for many years.

The process is the reduction of carbon dioxide with hydrogen and recovery of breathable oxygen by electrolysis of water.

The process "appears to be substantially superior to other processes considered." The apparatus involved has potentially a low weight, great reliability, and good efficiency with low power and energy consumption. Space vehicles probably will make trips of several years duration and will not be able to carry an adequate supply of oxygen. Reduction of carbon dioxide by hydrogen is a well known reaction that has been used by the gas industry to produce fuel gas.

ANTIBODY MOLECULES PHOTOGRAPHED

A new electron microscope technique has enabled scientists to take pictures of molecules of antibodies, a substance in the blood that fights disease-producing bacteria. A picture of rabbit antibody was obtained by spraying an antibody solution on a mica surface and then treating the surface with platinum, causing the tiny platinum particles to pile up against the antibody molecules like snowdrifts against a fence.

The Elementary School Science Library for 1959

Paul E. Kambly

School of Education, University of Oregon, Eugene, Oregon

This is the sixteenth yearly list of books for elementary school science compiled and published in SCHOOL SCIENCE AND MATHEMATICS. The purpose, like that of preceding lists, is to suggest to elementary school teachers books that are supplementary to basic text series either for their values as sources of information or for recreational reading. Certain books included primarily because of assumed value as recreational reading are below desired standards of good sources of science information. The sub-division topics are of no significance except as an aid in grouping the books.

Exact grade placement is difficult because of variations in pupil reading ability as well as in different uses made of the books. The lowest grade levels for pupils' use are indicated.

Books for Elementary School Science[1]

Ancient Animals

	Grade	*Price*
Dinosaurs. By Eunice Holsaert and Robert Gartland. 44 pp. '59. Holt. A first book of dinosaurs for the beginning reader.	2	$2.50
In the Days of the Dinosaurs. By Roy Chapman Andrews. 80 pp. '59. Random. Text and illustrations describe different types of dinosaurs and where and how they lived.	4	1.95
Before and After Dinosaurs. By Lois and Louis Darling. 94 pp. '59. Morrow. Describes the five subclasses of the class Reptilia. Many illustrations help to re-create the ancient times when dinosaurs lived.	5	2.95
Dinosaurs and Other Prehistoric Animals. By Darlene Geis. 105 pp. '59. Grosset. An attractive book with understandable text and many illustrations in color and in black and white. Also describes the work of the fossil hunter.	5	2.95

Animals

(See also list of books on birds and insects)

Houses from the Sea. By Alice E. Goudey. 32 pp. '59. Scribner. An entertaining book about shells found along a seashore. There are two pages at the end of the book showing the shells arranged and labeled with their common names.	1	2.95
Here Come the Raccoons. By Alice E. Goudey. 94 pp. '59. Scribner. Describes through a narrative account of one family the life cycle and habits of the raccoon.	2	2.50
Whitefoot Mouse. By Barbara B. Peterson and Russell F. Peterson. 52 pp. '59. Holiday. Accurate information about the life and habits of the animal and its relationship to other living things.	3	2.50

[1] Publishers and their addresses are listed at the end of this section.

	Grade	*Price*
Pigs, Tame and Wild. By Olive L. Earle. 64 pp. '59. Morrow. Illustrations on almost every page. Text treats briefly of the history, physical characteristics, and habits of the domestic pig, wild boar, wart hog, peccary, babirusa, pygmy hog, and hippopotamus.	4	$2.50
The Story of the Platypus. By Alfred G. Milotte. 114 pp. '59. Knopf The physical characteristics and life cycle of the Platypus. The community in which the animal lives is described in a very interesting manner.	4	2.75
The Weasel Family. By Charles L. Ripper. 64 pp. '59. Morrow. The physical characteristics, habits, and habitats of weasels, skunks, minks, otters, sea otters, martens, wolverines, and badgers.	4	2.50
Animal Habits. By George F. Mason. 93 pp. '59. Morrow. Instinct, intelligence, communication, neatness and cleanliness, affection and grief, nest building and survival are examined in short interesting chapters.	5	2.50
Animals That Help Us. Carroll Lane Fenton and Hermine B. Kitchen. 128 pp. '59. Day. A comprehensive study of the domestication of animals, historically developed.	5	3.50

Astronomy

The Sun, the Moon, and the Stars. By Mae and Ira Freeman. 82 pp. '59. Random. Most of the text and illustrations explain the characteristics of the solar system. Also describes a few constellations.	4	1.95
What Is a Solar System? By Theodore W. Munch. 48 pp. '59. Benefic. Relationships of planets to the sun and each other. Explains seasons and day and night.	4	1.60
Man in the Universe. By Michael Stoiko and Donald Cox. 42 pp. '59. Winston. Information about each planet's composition, orbit size, gravity, distance from the sun and speed of travel. Full page color illustrations.	4	2.95
Men, Planets and Stars. By Clyde B. Clason. 160 pp. '59. Putnam The major developments in astronomy from five hundred years before Christ to modern times. Emphasizes the contributions of various people to our understanding of astronomy.	5	2.95
The Nine Planets. By Franklyn M. Branley. 78 pp. '58. Crowell Each planet is described in detail. Distance, temperature, size, speed in its orbit, inclinations, mass and density are discussed. Includes information about how astronomers have made their discoveries.	5	3.00
Luther Burbank, Nature's Helper. By Lillian J. Bragdon. 124 pp. '59. Abingdon. The life story of Burbank and his achievements in the production of new and improved plants.	4	1.75
Charles Steinmetz. By Henry Thomas. 126 pp. '59. Putnam. This book emphasizes Steinmetz's life story rather than his scientific achievements but is very interestingly written.	5	2.50
Isaac Newton. By Beulah Tannenbaum and Myra Stillman. 128 pp. '59. Whittlesey. Newton's personal life and his work in mathematics, astronomy, gravity and optics are described in an interesting way.	5	3.00

	Grade	Price
Louis Pasteur—Fighting Hero of Science. By Madeleine P. Grant. 220 pp. '59. Whittlesey. The story of Pasteur's family life is interwoven with his work on crystals, microbes, fermentation and vaccines.	5	$3.25
Birds		
Peep-lo. By Jane Castle. 32 pp. '59. Holiday. A book about a little girl who finds a plover's nest and watches the young birds hatch from the eggs. A book with attractive illustrations for beginning readers.	1	2.50
Otus; the Story of a Screech Owl. By Lloyd Sandford. 47 pp. '59. Morrow. The life cycle, physical characteristics, habits and behavior of screech owl	2	2.50
Bobwhite from Egg to Chick to Egg. By Elizabeth and Charles Schwartz. 48 pp. '59. Holiday. A well written life cycle story with illustrations that will also be of interest to younger children.	3	2.50
Oliver Pete Is a Bird. By Carroll Lane Fenton and Dorothy Constance Pallas. 48 pp. '59. Day. Oliver Pete is a parakeet but the authors have written about the structure and habits of birds in general. An interesting well illustrated book.	3	2.75
Whooping Crane. By Robert M. McClung. 63 pp. '59. Morrow. The life cycle and habits of the whooping crane are described in a story about one particular bird and its family. Attractively illustrated and printed in large type.	3	2.50
Feathers and Flight. By Clarence J. Hylander. 214 pp. '59. Macmillan. An introduction to ornithology including physiology and anatomy, classification, flight, migration, mating, feeding and nesting habits. Identifies approximately 170 species of birds.	6	3.95
Fly, Redwing, Fly. By Lloyd Lozes Goff. 25 pp. '59. Lothrop. The life cycle and habits of the redwinged blackbird described in a narrative about one particular bird. Colored pictures on every page.	6	2.75
Conservation		
The True Book of Conservation. By Richard Gates. 48 pp. '59. Children's Press. Illustrated by the author who is an artist. He is primarily interested in helping young children understand the need for and meaning of conservation.	2	2.00
Man and the Good Earth. By Amabel Williams-Ellis. 64 pp. '59. Putnam. The importance of conservation of natural resources and what happens if conservation is not practiced. Emphasizes the importance of topsoil.	4	2.00
Water: Riches or Ruin. By Helen Bauer. 121 pp. '59. Doubleday Water and its relation to soil, what happens when there is too much or too little water, what has been done to control and utilize it to the best advantage, and ways in which everyone can help conserve it are explained.	4	3.00
General Nature Study		
The True Book of Jungles. By Illa Podendorf. 47 pp. '59. Children's Press.	2	2.00

	Grade	*Price*
Story of the plants and animals that inhabit the jungles of the world. Large illustrations in black and white and color.		
Grasslands. By Delia Goetz. 62 pp. '59. Morrow	3	$2.75
Prairies, steppes and savannas which cover a fifth of the earth's land surface are described.		
Let's Go for a Nature Walk. By Joan Rosner. 48 pp. '59. Putnam	3	1.95
Describes an imaginary trip for the purpose of learning about trees, wildflowers, insects and rocks.		
Soon After September. By Glenn O. Blough. 48 pp. '59. Whittlesey	3	2.50
Tells about plants and animals living during the winter where winters are cold and summers warm.		
Who Lives in a Field. By Duryea Morton. 126 pp. '59. Coward-McCann	3	3.00
Includes information about the Barred Owl, White-footed Mouse, Short Tailed Shrew, Woodchuck, Rabbit and Grey Fox.		
Aquarium Book for Boys and Girls. By Alfred Morgan. 210 pp. '59. Scribner	4	3.00
A revised edition of a book first published in 1936. An excellent source of information on setting up and maintaining an aquarium or vivarium.		
Life Under the Miscroscope. By William M. Hutchinson. 32 pp. '59. Children's Press	4	1.50
A beginner's book about algae, protozoans and small multicellular organisms. Includes material on the structure and use of a microscope.		
Wild Folk at the Seashore. By Carroll Lane Fenton. 128 pp. '59. Day	4	3.50
The appearance and life habits of the more common animals and plants of the Atlantic, Pacific and Gulf coasts of the U. S.		
Wonders Under a Microscope. By Margaret Cosgrove. 62 pp. '59. Dodd	4	2.95
How to use a microscope and the kinds of things that can be seen. Some information about scientists who have made discoveries by using a microscope.		
All About the Jungle. By Armstrong Sperry. 142 pp. '59. Random	5	1.95
A journey through the rain forests of Brazil, the East Indies and the Belgian Congo. Includes material about the people who live in jungles as well as about other animals and plants.		
The World of the Microscope. By Laurence James Ludovici. 128 pp. '59. Putnam	5	2.95
Traces the work and achievements of scientists from Darwin to Salk and explains the discovery and understanding of microbes and the conquest of disease. Discusses how scientific knowledge accumulates and how each important discovery is related to those that precede or follow it.		
Strange Partners. By Sigmund A. Lavine. 106 pp. '59. Little	6	2.75
Alliances between living things such as the rhinoceros and tickbird, alga and fungus, ants and aphids and the sea anemone and clownfish.		

General Science

About Wonderful Wheels. By Feenie Ziner. 24 pp. '59. Melmont	1	2.50
A beginner's book about wheels and how man uses them to get work done.		
Timmy and the Tin-can Telephone. By Franklyn Mansfield. Branley and Eleanor K. Vaughan. 35 pp. '59. Crowell	1	2.50
To assist Timmy and his next door neighbor communicate with		

	Grade	*Price*
each other without waking families and neighbors Timmy's father helps them make a telephone from two tin cans and a piece of string. The story and the drawings on every page give directions for constructing a workable tin-can telephone.		
Sounds All Around. By Tillie S. Pine and Joseph Levine. 47 pp. '58. Whittlesey. An elementary explanation of sound—what causes sound, how it travels, how it can be pitched high or low, softened, made louder, or stopped and how it can be used for fun. Suggests experiments which utilize materials found in the home.	2	$2.50
Water All Around. By Tillie S. Pine and Joseph Levine. 48 pp. '59. Whittlesey. Tells about all kinds of water in all kinds of forms. Suggests some simple experiments with water.	2	2.50
Simple Machines and How They Work. By Elizabeth N. Sharp. 84 pp. '59. Random. An excellent easy to read description of the wheel, screw, lever, wedge and inclined plane and how they make man's work easier. Clear, large illustrations supplement the text.	3	1.95
Geology. By Catherine E. Orr and M. Vere DeVault. 48 pp. '59. Steck. Text and illustrations explain erosion, mechanical weathering, chemical weathering, minerals, rocks and fossils.	4	1.75
Let There Be Light. By Lillian J. Bragdon. 91 pp. '59. Lippincott. The story of man's discovery and use of fire, coal, gas, oil and electricity as sources of light. Also explores future possibilities in lighting.	4	2.75
Magic, Science and Invention. By Amabel Williams-Ellis. 64 pp. '59. Putnam. Includes stories of people such as Linnaeus, Madame Curie and Orville Wright. Through these stories the author emphasizes the methods used in making new discoveries.	4	2.00
Our World of Science. By Duane Bradley and Eugene Lord. 159 pp. '59. Lippincott. Suggests activities that help to answer questions about air, water, physical and chemical changes, motion, sound, light, heat and electricity.	4	3.00
Physics. By Claude C. Boyd and M. Vere DeVault. 48 pp. '59. Steck. A book of simple demonstrations in the areas of heat, mechanics of gases, light, mechanics of motion, static electricity and sound. Numerous drawings supplement the text.	4	1.75
Rocks All Around Us. By Anne Terry White. 84 pp. '59. Random How rocks are formed and some of the materials man makes out of rocks. Includes information about some common rocks but is not intended primarily as a book to help identify rocks.	4	1.95
Science for Children. By Muriel Mandell. 96 pp. '59. Sterling. A book of experiments designed to help children answer the questions they ask. Numerous line drawings help clarify the text.	4	2.50
The Answer Book. By Mary Elting. 158 pp. '59. Grossett. Divided into ten chapters beginning with answers about questions dealing with space and space travel and ending with a chapter called "Mysteries."	4	3.95
The Unknown Ocean. By Amabel Williams-Ellis. 72 pp. '59. Putnam. How man explores the ocean depths with aqualung and fins and	4	2.00

	Grade	*Price*
for greater depths the bathysphere. Describes some of the living things that have been found.		
What Is a Magnet? By Gabriel H. Reuben and Gloria Archer. 48 pp. '59. Benefic Easily understood material covering the basic ideas of magnetism.	4	$1.60
What Is a Rock? By B. John Syrocki. 48 pp. '59. Benefic Basic information on how rocks tell us about life long ago, the earth's changes, and water levels. Colored illustrations supplement the text.	4	1.60
All About Archaeology. By Anne Terry White. 148 pp. '59. Random What archeologists do and how they help us understand how man lived thousands of years ago. Includes some of the very interesting discoveries such as the treasure of Ancient Greece and Troy and the palace of Minos with its hundreds of rooms.	5	1.95
All About Prehistoric Cave Men. By Sam and Beryl Epstein. 137 pp. '59. Random The story of people who lived hundreds of thousands of years ago. Includes the Peking Men, Neanderthal cave dwellers and the Cro-Magnons.	5	1.95
All About the Ice Age. By Patricia Lauber. 152 pp. '59. Random Tells about the period of time when a quarter of all the land on earth was covered with ice and how sckentists have attempted to explain why it happened.	5	1.95
Clouds. By Thomas McGrath. 31 pp. '59. Melmont An elementary explanation of the various kinds of clouds and what they mean weatherwise, presented in attractive pictures and very brief text.	5	2.00
Diamonds. By Herbert Zim. 64 pp. '59. Morrow Interesting facts about diamonds—how they are formed, where they are found, their characteristics, how they are mined and cut, their industrial uses, famous gems, and the manufacture of synthetic diamonds.	5	2.50
Hot and Cold. By Irving Adler. 128 pp. '59. Day An explanation of heat and its measurement, why smoke rises, why a pond freezes from the top, how an electric current makes heat and how man uses heat to help him do work.	5	3.00
Mechanical Man. By Berl Becker. 192 pp. '59. Putnam The wonders of man's progress in developing machines beginning with DaVinci's contributions through the machines important in the industrial revolution and ending with a chapter on the Age of Space.	5	2.95
Sending the Word; the Story of Communication. By Walter Buehr. 95 pp. '59. Putnam Man's development of methods for transmitting, preserving, and reproducing ideas. Illustrated with many drawings.	5	3.00
Television Works Like This. By Jeanne and Robert Bendick. 64 pp. '59. Whittlesey A third revision of a book first published in 1949. Text and illustrations tell the behind-the-scenes story of television. New material discusses pay television, closed circuit television and video tape.	5	2.75
The Book of Experiments. By Leonard deVries. 123 pp. '59. Macmillan One hundred and fifty different activities many of which will help children learn various phases of science. Each experiment	5	3.00

	Grade	*Price*
or activity has a title, a list of materials needed and a description of what to do.		
The Genie and the Word. By Walter Buehr. 88 pp. '59. Putnam. Tells how Samuel Morse invented the first successful telegraph and how other men such as Cyrus Field and Marconi developed other means of communication.	5	$3.00
The Storybook of Science. By Earl Schenck Miers. 159 pp. '59. Rand. The eight areas included are electricity, electronics, heat, food, wheels, the sky, the universe and the atomic age.	5	2.95
Weather in Your Life. By Irving Adler. 126 pp. '59. Day. Includes weather phenomena, their causes and effects, weather forecasting. Also discusses briefly man's efforts to control the weather. Illustrated with drawings, photographs, and diagrams.	5	3.00
Young Scientist Takes a Walk. By George Barr. 160 pp. '59. Whittlesey. Investigates such things as sounds, odors, stones, metals, erosion, trees, plants, birds, insects and the sky.	5	3.00
Atoms Today and Tomorrow. By Margaret O. Hyde. 159 pp. '59. Whittlesey. A revision of a book first published in 1955. Emphasizes the peacetime uses of atomic energy. Line drawings supplement the text.	6	3.00
Men, Ants and Elephants. By Peter K. Weyl. 104 pp. '59. Viking An excellent discussion of the range in size of living things and how size affects our ability to do things. A book for the best sixth grade pupils.	6	3.00
Mr. Wizard's Experiments for Young Scientists. By Herbert Don. 187 pp. '59. Doubleday. Thirteen projects demonstrate scientific principles and introduce the reader to techniques of various types of scientists.	6	2.95
Push and Pull; the Story of Energy. By Paul E. Blackwood. 190 pp. '59. Whittlesey. What energy is, the different kinds of energy, and how energy is transformed, controlled, and used. Predicts future developments.	6	3.00
Window in the Sky. By Homer E. Newell, Jr. 116 pp. '59. McGraw-Hill. The story of our upper atmosphere—its composition, density, pressure, temperature and radiation. Included for the best sixth grade pupils.	6	2.75
Words of Science and the History Behind Them. By Isaac Asimov. 266 pp. '59. Houghton. Over 1500 scientific words explained by an exploration into their roots and history.	6	5.00
Insects		
Bees and Wasps. By Valerie Swenson. 30 pp. '59. Maxton. Describes different kinds of bees and wasps. Good illustrations supplement the text.	4	1.50
Insect Buildings and Craftsmen. By Ross E. Hutchings. 96 pp. '59. Rand. The habits, behavior and home-building methods of the paper hornet, carpenter bee, mud dauber, leaf cutter, caddis worm and termite. Illustrated with excellent photographs.	5	2.95
Physiology		
Your Body and You. Alice Hinshaw. 48 pp. '59. Children's Press.	2	2.00

	Grade	*Price*
Simple text and illustrations explain the structure and function of the human body.		
Physiology. By Jessie Helen Haag and M. Vere DeVault. 48 pp. '59. Steck	4	$1.75
For each concept developed there is also a suggested demonstration. Text includes material about food, breathing, circulation, the nervous system, muscles, skin and the eye.		
You, Yourself. By Elizabeth Lyttleton. 72 pp. '59. Putnam	4	2.00
Chapter headings are 1. Who Are You and What Are You? 2. What Are You Made of? 3. You and the Animal Kingdom. 4. Your Body and How It Works. 5. How We Learned About the Human Body. 6. You and Your World.		
Your Heart and How It Works. By Herbert S. Zim. 63 pp. '59. Morrow	5	2.50
The function, structure and diseases of the heart are explained with excellent drawings and diagrams.		
Plants		
Seeds and More Seeds. By Millicent Selsam. 60 pp. '59. Harper	3	2.50
Benny learns by experimentation and observation what seeds are, how they grow, where they come from, and how they are dispersed.		
Plants That Changed the World. By Bertha S. Dodge. 183 pp. '59. Little	6	3.50
Describes some of the men who have searched for useful plants and the important products that are made from the plants they found.		
Plants That Heal. By Millicent Selsam. 96 pp. '59. Morrow	6	2.50
Plant remedies from the herbs of primitive societies to the drugs of modern medicine. Describes the discovery and uses of such plant derivatives as cortisone, chaulmoogra, reserpine, digitalis, castor oil, belladonna, penicillin, terramycin, and vitamins.		
Rockets, Jets and Space Travel		
A Book of Satellites for You. By Franklyn M. Branley. 38 pp. '58. Crowell	1	3.00
An introduction to the space world with emphasis on man made satellites and how they work.		
You Will Go to the Moon. By Mae Freeman and Ira M. Freeman. 54 pp. '59. Random	1	1.95
Simple text and colored pictures explain how a trip to the moon will be made.		
Outer Space. By Eunice Holsaert. 46 pp. '59. Holt	2	2.50
An introduction to outer space for the beginning reader.		
The True Book of Space. By Illa Podendorf. 48 pp. '59. Children's Press	2	2.00
A beginner's book on satellites, space travel and rockets.		
Off Into Space. By Margaret O. Hyde. 63 pp. '59. Whittlesey	3	2.50
An imaginary trip to the moon helps to explain such things as gravity, atmosphere, planets and the principles of rocket flight.		
Rockets into Space. By Alexander L. Crosby and Nancy Larrick. 82 pp. '59. Random	4	1.95
The story of rockets and how modern rockets work. Well illustrated and easy to read. Includes material on man's plans to reach the moon and what living conditions are like on the moon.		
What Is a Rocket? By Theodore W. Munch. 48 pp. '59. Benefic	4	1.60
An explanation of the theory of flight and use of rockets. Illustrations in color.		

	Grade	*Price*
About Missiles and Men. By Edward and Ruth Shaw Radlauer. 46 pp. '59. Melmont. Excellent photographs and clear text explain how men pool their efforts to build and fire a missile.	5	$2.50
Our Space Age Jets. By Carroll B. Colby. 48 pp. '59. Coward-McCann. A new and revised edition of *Our Fighting Jets.* Statistics about 23 aircraft which show the advances in design since 1951.	5	2.00
Rocketry Through the Ages. By Donald Cox and Michael Stoiko. 42 pp. '59. Winston. Full color illustrations face each page of the text. Includes Hermes, Viking, Thor Able, Jupiter C, Atlas, and the X15.	5	2.95
Rockets, Missiles and Satellites. By Clayton Knight. 62 pp. '58. Grosset. Primarily a book of illustrations of the various types of rockets and aircraft. Text explains how rockets are launched and may be used as weapons of destruction.	5	1.95
Seeing the Earth from Space. By Irving Adler. 160 pp. '59. Day. Reports on each of the new moons man has launched and the information about the earth that has been gained because of them. A book for good students.	6	3.50
Transportation		
The Engineer of a Train. By Siddie Joe Johnson. 32 pp. '59. Melmont. Large illustrations and easy to read text explain the duties of the fireman, brakeman, conductor and engineer of a train. Also explains the type of signals used by railroads.	2	2.50

Publishers and Their Addresses

Abingdon: Abingdon-Cokesbury Press, 810 Broadway, Nashville 2, Tennessee.
Benefic: Beckley Cardy Company, 1900 N. Narragansett, Chicago 39, Illinois.
Children's Press: Children's Press, Jackson Blvd. and Racine Avenue, Chicago 7, Illinois.
Coward-McCann: 210 Madison Avenue, New York 16, New York.
Crowell: Thomas Y. Crowell Company, 432 Fourth Avenue, New York 16, New York.
Day: The John Day Company, 121 Sixth Avenue, New York 13, New York.
Dodd: Dodd, Mead and Company, Inc., 432 Fourth Avenue, New York 16, New York.
Doubleday: Doubleday and Company, Inc., 575 Madison Avenue, New York 22, New York.
Grosset: Grosset and Dunlap, Inc., 1107 Broadway, New York 10, New York.
Harper: Harper and Brothers, 750 Third Avenue, New York 17, New York.
Holiday: Holiday House, 8 West Thirteenth, New York 11, New York.
Holt: Henry Holt and Company, Inc., 383 Madison Avenue, New York 17, New York.
Houghton: Houghton Mifflin Company, 2 Park Street, Boston 7, Massachusetts.
Knopf: Alfred A. Knopf, Inc., 501 Madison Avenue, New York 22, New York.
Little, Brown: Little, Brown and Company, 34 Beacon Street, Boston 6, Massachusetts.
Lippincott: J. B. Lippincott Company, 227–231 South Sixth Street, Philadelphia, 5, Pennsylvania.
Lothrop: Lothrop, Lee and Shepard Company, Inc., 419 Fourth Avenue, New York 16, New York.

McGraw: McGraw-Hill Company, 330 West Forty-second Street, New York 36, New York.
Macmillan: The Macmillan Company, 111 New Montgomery Street, San Francisco 5, California.
Maxton: Maxton Publishers, Inc., 15 East Twenty-Sixth Street, New York 10, New York.
Melmont: Melmont Publishers, Inc., 310 South Racine Avenue, Chicago 7, Illinois.
Morrow: William Morrow and Company, 425 Fourth Avenue, New York 16, New York.
Putnam: G. P. Putnam's Sons, 210 Madison Avenue, New York 16, New York.
Rand: Rand McNally and Company, 111 Eighth Avenue, New York 11, New York.
Random: Random House, Inc., 457 Madison Avenue, New York 22, New York.
Scribner: Charles Scribner's Sons, 597 Fifth Avenue, New York 17, New York.
Steck: Steck Company, Ninth and Lavaca Streets, Austin 1, Texas.
Sterling: Sterling Publishing Company, Inc., 419 Fourth Avenue, New York 16, New York.
Viking: The Viking Press, 625 Madison Avenue, New York 22, New York.
Winston: John C. Winston Company, 1006–1020 Arch Street, Philadelphia 7, Pennsylvania.
Whittlesey: McGraw-Hill Company, 330 West Forty-second Street, New York 36, New York.

YEAR-LONG TESTS CONFIRM EINSTEIN'S RELATIVITY THEORY

Year-long tests, believed the most precise yet made, have confirmed preliminary results by the same method that Einstein's special theory of relativity is correct.

The experiments showed no measurable variation in frequency of radio waves radiated by ammonia molecules as the earth moved around the sun during a year. Einstein's special theory postulated that the velocity of light, 186,000 miles a second, is independent of its frame of reference or of the motion of the light source itself. It also applies to radio waves, which travel at the speed of light.

Results of the experiments, conducted at Columbia University at the suggestion of Novel Prize winner Dr. Charles H. Townes, are reported in *Nature*, a British scientific publication. His associates found that, at most, less than one-thousandth of the earth's velocity around the sun could affect the speed of light propagation.

High precision of the tests was possible by using two masers. The coined word maser stands for "microwave amplification by stimulated emission of radiation." Previous experiments, starting with the classic Michelson-Morley tests, have confirmed Einstein's theory but not as precisely as the present test.

NEW METHOD FOR MAKING VERY HIGH VACUUM FOUND

A new method for making extremely high vacuums, some ten-billionths less than normal, has been reported.

The vacuum-producing system was found while studying the effects of rotors spinning at very high rates in a vacuum. Its advantages include the fact that the extremely high vacuum can be achieved very quickly, the apparatus can be refrigerated to very low temperatures while in operation.

The pumping system does not use any lubricated bearings.

A Model Foucault Pendulum

John J. Bowen
Chicago Teachers College, Chicago, Illinois

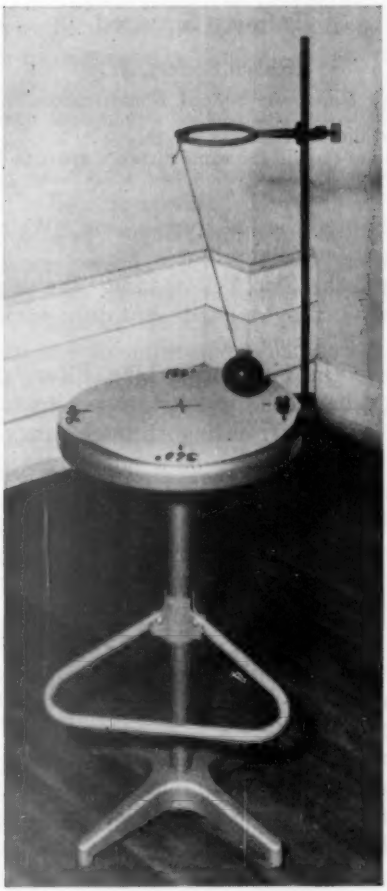
One of the most compelling items of evidence in support of the concept of a rotating earth has been the Foucault pendulum. There are numerous historical and analytical treatments of this pendulum in the literature of science, but the analytical ones are, generally, too sophisticated for any but the college student of physics.

From the standpoint of students in the elementary or secondary years, the greatest barrier to the understanding of the significance of the Foucault pendulum seems to be lack of knowledge of the properties of a pendulum in general. Students are much more likely to know that the period of a pendulum is a function of its length, than they are to know that the plane of oscillation of a pendulum tends to remain fixed in space. When students are convinced that this latter property is, indeed, true, they are ready to appreciate the significance of a film or demonstration of a full-scale Foucault pendulum.

Rather than mention this famous experiment and then briefly state that a pendulum does have a fixed plane of oscillation in an anybody-knows-that tone, a teacher will find it more satisfactory to show how a model pendulum operates on both a fixed and moving platform. A very simple way to show this property is to hang a weight from a ring stand placed on a freely-turning stool, as shown in the accompanying photograph. The flexibility of the string is an adequate bearing, and the weight can be any object of 500 grams or more. The marking of the base in degrees is not necessary, but a chalked reference line on the stool is helpful.

If the pendulum is mounted so that it is directly over the axis of the stool when at rest, this is analogous to hanging a pendulum at either the north or south pole of the earth. If the pendulum is started swinging while the stool is at rest, it behaves as a group of students would expect and maintains a fixed plane of oscillation with respect to the stool and the walls of the room. A teacher can often excite considerable interest by asking a class to predict what will happen, if the stool is rotated while the pendulum is swinging. A large number of the students will assume that the pendulum will follow the stool, since it supports the ring stand. The actual events can be the basis of a profitable class discussion.

If the pendulum is again started in a given plane, and the stool is rotated slowly and uniformly, it will be obvious that the pendulum retains its plane of oscillation with respect to some point either in the room, on the earth, or in space, and that it does not follow the rotat-



ing stool. When a class has seen this demonstration, a teacher can then turn to the behavior of a full-scale Foucault pendulum and the earth in space.

A class can use the model to investigate and predict the behavior of the large pendulum if the earth were stationary, rotating right or left, or with the pendulum at either the north or south pole.

This demonstration is limited because it only illustrates the behavior of the Foucault pendulum at one of the poles and does not show what would happen at some other latitude. Because our model depends upon the gravitational field of the earth and not upon one directed toward the center of the stool, we can only illustrate this special polar case.

Infinity Squared

Ralph Seifert, Jr.

Student, University School, Bloomington, Indiana

A straight line is of infinite length.
Parallel lines remain the same distance apart to Infinity.
—geometrical axioms

"There it is!" shouted the Fat Purple Line. "We're almost there—we're getting closer—we're here!"

"At last!" exulted the Thin Yellow Line. "We've reached Infinity! All Lines end here—if they're good—but only *parallel* lines come in together!"

"At last!" echoed the Fat Purple Line. "Ever since that plump little first-grade girl happened to draw us parallel to each other with her crayons, we've been traveling through space. Now we have reached Infinity together! But let's not forget our friends who dropped by the wayside."

"Yes," replied the Thin Yellow Line. "Those fine, upstanding Lines that were not parallel to us. One by one they crossed us and went shooting off in their own directions, to reach Infinity alone and spend the rest of their days in relative solitude."

"The Thick Magenta Line was the first to go," mused the other. "Then the Variable Cobalt Blue Line—"

"And poor Wiggly Red Line—he wasn't even straight! He never had a chance. Yes, he was completely unparalleled!"

"We alone, of all the scribblings on that messy art paper, remain companions at Infinity. Let us contemplate the glorious scene."

The wonders of the region of Infinity were these: As far as the eye could see were Lines of every color and description. Some met, and some did not. There were fat Lines, skinny Lines, thick Lines and thin ones; solid Lines, dashed, dotted, and irregular ones; and Lines rang-

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EDITOR'S NOTE: Readers may be interested in this teacher's letter and the student's article.

Mr. George G. Mallinson, Editor
SCHOOL SCIENCE AND MATHEMATICS
Western Michigan University
Kalamazoo, Michigan

Dear Mr. Mallinson:

Ralph Seifert, a student in my high school senior English class in the University School, is the author of the enclosed manuscript. At the suggestion of Dr. Philip Peak, I am submitting it for your consideration for SCHOOL SCIENCE AND MATHEMATICS.

The concepts of modern mathematics exemplified in this short-short story might suggest to teachers of math the impact that such teaching can make on students. In addition to this fact, this piece of writing suggests how English teachers can also capitalize on the abilities of many students whose interests are primarily math and science.

Sincerely,
JOSEPHINE SPEAR
Chairman of English Department
University School

ing in hue from vermilion to hypochondriac green. There were thin black pencil Lines from geometry classes. There were dotted Lines from used-car contracts and insurance policies. There were telephone Lines, French Lines, deadlines (none of these met), in-Lines and out-Lines.

The Fat Purple Line and the Thin Yellow Line, after looking around, attempted to become acquainted with their nearer neighbors.

"Ho," shouted the Fat Purple Line to a matched pair of parallel Brilliant Golden Lines nearby. "You are the grandest and greatest Lines in the vicinity; tell us your names, in order that we may become acquainted." There was no reply.

"They will not answer," commented a Thin Green Line to the east. "Since, when they were drawn, they were 3.14159 inches apart, they think they are superior. They speak only to the Very Old Line who is over there to the north."

"He appears quite ragged," said the Thin Yellow Line. "Note the irregularity of his dots and dashes."

"That is only from his great age," retorted the Thin Green Line. "He is the most highly respected Line in the vicinity—the most distinguished Line within 83,427 miles of here."

"By the five-sided square," swore the Fat Purple Line, "what did he do?"

"He was drawn by Archimedes himself," whispered the Thin Green Line.

"I presume he is friendly," said the Thin Yellow Line.

"No, he is just as bad as the two Golden Lines. He speaks only to the great and powerful Gamma-Delta (83,427 miles away), who was drawn by Father Euclid, the All-High."

At this point the conversation was suddenly interrupted by a blinding flash in the very midst of the assembled Lines. When their eyes had recovered, they saw, standing amongst them and staring wide-eyed at everything, a being which they had never before seen.

It was a Square.

Naturally, they all knew that such a thing was possible—voyaging through space for infinite periods of time gives one a chance to think about such things—and indeed, when four Lines crossed each other in the right way, a Square could be seen—but it was an inanimate Square. This one wasn't.

"Who are you," thundered Gamma-Delta, "and whence come you?"

"I am a Square," said the Square, "and I come from the World of Academic Mathematics."

"How came you here?" asked Gamma-Delta.

"'Tis indeed a sad story," began the Square. "Look at me, a

perfect Square, every side equal, every angle correct to the fraction of a second, uprooted from his home and transported to—yes, where am I?"

"You are at Infinity," quoth Gamma-Delta, "where all straight Lines go if they are good."

"I *have* come a distance, haven't I?" replied the Square. "Originally," he began again, "I was drawn with the finest India ink on a piece of paper by an Academic Professor who wanted to demonstrate the formula $A=s^2$ to a group of elementary students. In his next class, the professor wished to demonstrate to a more advanced group something about a four-dimensional matrix or something, and, in an effort to explain, he seized the paper to which I was clinging and twisted it in such an extraordinary manner that I was flung through the Fourth Dimension and deposited here."

"Very odd," remarked Gamma-Delta.

"Poor me," lamented the Square. "At my young age—uprooted and flung into Infinity—a refugee from a class in Non-Euclidian Geometry."

At the mention of these last forbidden words, the entire group of Lines was thrown into a state of extreme shock. Had the Lines been capable of motion, they would have turned upon the Square and transfixed him on the spot.

"Profane Quadrilateral!!" shouted Gamma-Delta. "How dare you imply that there is any Geometrical System besides that of the Great and All-Powerful, Father Euclid?!?!?"

"I wouldn't shout about who knows what," said the Square. "Why, I'll bet you don't even know where your other end is."

"My other end?" said Gamma-Delta, briefly puzzled.

"Yes," replied the Square. "All Lines have two ends. One of yours is here, at Infinity. Where is the other?"

"Naturally, it is also at Infinity."

"*I* don't see it," said the Square. "All I see is your head end and your body, which stretches like so much spaghetti into Inner Space."

"My other end is on the other side of Infinity," said Gamma-Delta.

"In other words, you extend an infinite distance on both sides of your point of origin."

"That is correct," said Gamma-Delta in a self-satisfied voice.

"But that means that your length is two times infinity, which is equal to infinity, making you only half as long as you are, no matter how long you were to begin with."

"Uh—"

"Besides, your other end should be here! Are you unfamiliar with the simple concept of Curved Space?!?"

These words so confused poor Gamma-Delta that he disappeared in a great purplish-blue flash, as though his linear body had been turned into a flashbulb filament. A small pencil Line who had been in attendance at the court also vanished, but not so spectacularly—only as if he had been erased.

This victory won, the now enraged Square turned on the assembled company and demolished them all with a sparkling stream of Higher Mathematics Rhetoric that their pitiful one-dimensional brains would never have conceived by themselves. Then he started off to destroy all of Infinity, if necessary, to prove the merits of non-Euclidian geometry.

But, of course, since Infinity was infinite in extent, he never succeeded.

PROBLEM DEPARTMENT

Conducted by **Margaret F. Willerding**

San Diego State College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the Department desires to serve her readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, San Diego State College, San Diego, Calif.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Solutions should be in typed form, double spaced.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

4. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

2694, 2701, 2702. *C. W. Trigg, Los Angeles, Calif.*

2708, 2710, 2711, 2712. *Merrill Barnebey, Tougaloo, Miss.*

2710, 2711, 2712, *Herbert R. Leifer, Pittsburgh, Pa.*

2710. *Floyd Wilder, Bethany, Okla.*

2691. *Proposed by C. W. Trigg, Los Angeles City College.*

There are two numbers each with three like middle digits, and such that each of their squares is a permutation of the digits from zero through eight. Find them and show that there are no others.

Solution by the proposer

1. Evidently the first digit of N^2 cannot be zero, so

$$102345678 < N^2 < 876543210$$

and

$$10116 < N < 29607.$$

2. The sum of the digits of N^2 is 36, so N^2 is divisible by 9, hence N is divisible by 3. Now the sum of the three middle digits is divisible by 3, so if N begins with 1 it must terminate with 2, 5 or 8. If N begins with 2 it must terminate with 1 or 4. (Not with 7, which would cause N^2 to terminate with 9.) The middle digits might be any of the ten digits which would keep N in the range

$$11112 \leq N \leq 28884.$$

Thus there are 45 possible values of N.

3. Since the last k digits of N determine the last k digits of N^2, it is possible to eliminate 32 of the possible values of N without completing the squaring process. When the remaining 13 values are completely squared, duplicate digits or 9's appear in all but

$$(14442)^2 = 208571364,$$

and

$$(17778)^2 = 316057284.$$

[Also, $(24441)^2 = 597362481$.]

2713. *Proposed by Walter R. Talbot, Jeffrson City, Mo.*

Verify the inequality

$$\frac{1}{4} < \frac{\sqrt{5}+1}{5\sqrt{(10-2\sqrt{5})}} < \frac{\sqrt{3}}{6}.$$

Solution by the proposer

Square all the members and rationalize the denominator of the middle term to give

$$\frac{1}{16} < \frac{(6+2\sqrt{5})(10+2\sqrt{5})}{25(10-2\sqrt{5})(10+2\sqrt{5})} < \frac{3}{36}$$

or

$$\frac{1}{16} < \frac{5+2\sqrt{5}}{125} < \frac{1}{12}.$$

Invert and reverse the inequalities to give

$$12 < \frac{125}{5+2\sqrt{5}} < 16.$$

Rationalize the middle denominator to give

$$12 < 125 - 50\sqrt{5} < 16.$$

This step is valid if

$$125 - 16 < 50\sqrt{5} < 125 - 12.$$

On squaring all members, we find it is true that

$$11\ 881 < 12\ 500 < 12\ 769.$$

By reversing the steps the original inequality may be derived.

Solutions were also submitted by Richard Lamb, Naperville, Ill., and Dale Woods, Kirksville, Mo.

2714. *Proposed by Cecil B. Read, Wichita, Kans.*

The numbers 1, 2, 3, $\cdots$, $2n$ are arranged consecutively around a circle at equal intervals. Through one of these numbers, h, a diameter is drawn. For what values of n and h will the sum of the numbers on one side of the diameter be equal to the sum of those on the other?

Solution by Charles H. Butler, Kalamazoo, Mich.

If n is an odd number, then $\frac{1}{2}n$ is not an integer, but $(\frac{1}{2}n+\frac{1}{2})$ is an integer and is one of the integers placed on the circle. Now let h be taken as $(\frac{1}{2}n+\frac{1}{2})$. Then the diameter drawn through h will be the one required. The argument is as follows.

If the diameter is drawn in this manner, then each chord drawn from one of the numbers and parallel to this diameter will end in another of the numbers, and in every such case the sum of these two numbers will be $(2n+1)$. This is true because in and only in such an arrangement the largest number $(2n)$ will be paired with the smallest (1), the next largest $(2n-1)$ with the next smallest (2), etc. These chords are symmetrically placed with respect to this diameter, so exactly half of these number pairs (all having equal sums) will be on each side of this diameter. Hence the sum of the numbers on one side of this diameter will be the same as the sum of the numbers on the other side.

Similar considerations would apply when n is even, except that h must be an integer, and if n is even then $h(=\frac{1}{2}n+\frac{1}{2})$ would not be an integer. Hence the requirements of the problem will be satisfied if and only if n is an odd number and $h=(\frac{1}{2}n+\frac{1}{2})$.

Solutions were also submitted by W. R. Talbot, Jefferson City, Mo., Dale Woods, Kirksville, Mo., and the proposer.

2715. No solution has been submitted.

2716. *Proposed by Brother Felix John, Philadelphia, Pa.*

The following equations have a common root. Determine a, b, and c, if possible.

$$ax^2+3x+c=0$$
$$3x^2+bx+c=0$$
$$2ax^2+(b+2)x-2=0$$

Solution by Dale Woods, Kirksville, Mo.

If r is the common root we have

$$ar^2+3r+c=0$$
$$3r^2+br+c=0$$
$$2ar^2+(b+2)r-2=0$$

Solving this system for a, b, and c we have

$$a=\frac{3r^2-5r+2}{3r^2};\qquad b=\frac{-6r^2+4r+2}{3r};\qquad c=\frac{-3r^2-4r-2}{3}$$

Hence for any value of r we have values of a, b, c such that the equations have a common root.

Solutions were also submitted by W. R. Talbot, Jefferson City, Mo.; and the proposer.

2717. No solution has been submitted.

2718. No solution has been submitted.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted to this department. Teachers are used to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

2716. *Nicholas V. Kleszczewski, Chicago, Ill.*

PROBLEMS FOR SOLUTION

2737. *Proposed by C. W. Trigg, Los Angeles, Calif.*

The familiar "prime" formula, $f(n)=n^2-n+41$, has many composite values for $n \geq 41$. Find the value of n for which $f(n)$ is palindromic with the sum of its two prime factors equal to 440.

2738. *Proposed by D. Moody Bailey, Princeton, W. Va.*

P is the center of the nine point circle of triangle ABC. Rays from the vertices A, B, and C are drawn through P meeting the opposite sides a, b, and c at points D, E, and F respectively. Determine the values of the ratios BD/DC, CE/EA, and AF/FB in terms of the sides a, b, and c.

2739. *Proposed by Donald R. Byrkit, West Chicago, Ill.*

Find Q consecutive perfect squares whose sum is a perfect square, $3 \leq Q \leq 20$.

2740. *Taken from* More Problematical Recreations.

If each of the letters A, B and C represents a particular digit, what is the minimum value of the whole number ABC divided by $A+B+C$? (The answer is not one.)

2741. *Proposed by Brother Felix John, Philadelphia, Pa.*

A sphere with a diameter of e units is tangent to the faces of a trihedral angle whose face angles are right angles. Another sphere is tangent to this sphere and to the three faces. Find the radius of the second sphere.

2742. *Proposed by G. P. Speck, Virginia, Minn.*

Prove

$$\sum_{n=1}^{\infty} \frac{1}{n^2+1} = \tfrac{1}{2}(\pi e^{\pi} \operatorname{csch} \pi - \pi - 1).$$

For the past three months this department has offered two problems especially for high school students. All teachers are encouraged to have their students submit problems and solutions for this special section of the Problem Department. If the Editor feels that there is enough interest in this special section of the Problem Department the Student Problems will become a regular part of the Problem Department in the Fall.

Students sending in solutions and submitted problems for solution should observe the following instructions:

1. Each solution must be in typed form, double spaced.
2. Drawings, in India ink, should be on a separate page from the solution or proposal.
3. Problems and solutions should be in the same form that appears in the Journal.
4. Each problem should be on a separate sheet of paper.
5. In general when several solutions are correct, the one submitted in the best form will be used.

STUDENT PROBLEMS FOR SOLUTION

S-7. *Proposed by Harry Frye, Tullahoma, Tenn.*

Find the greatest area of the integral right triangle whose hypotenuse is 325.

S-8. *Proposed by Lee H. Mitchell, Glencoe, Ill.*

Prove sin $2nx$ has the factor $2 \sin x \cos x$, where n is an integer.

Books and Teaching Aids Received

FIRST PRINCIPLES OF CHEMISTRY, by Moddie D. Taylor, *Professor, Department of Chemistry, Howard University.* Cloth. Pages xxii+688. 23×15 cm. 1960 D. Van Nostrand Company, Princeton, New Jersey. Price $7.50.

ICE AGE COMING?, by Leverett G. Richards. Cloth. 128 pages. 20.5×14 cm. 1960. The John Day Company, Inc., 210 Madison Ave., New York, N. Y. Price $3.25.

AN INTRODUCTION TO MODERN MATHEMATICS, by Robert W. Sloan, *Professor of Mathematics, State University of New York, College of Education at Oswego.* Cloth. Pages xi+73. 21×14.5 cm. 1960. Prentice-Hall, Inc., 70 Fifth Ave., New York 11, N. Y. Price $3.75.

THEORY OF DIFFERENTIAL EQUATIONS, by Andrew Russell Forsyth, *Fellow of Trinity College, Cambridge.* Six volumes bound as three. All cloth. All 20.5×13 cm. Vol. one and two, xiii+344 pages. Vol. three and four, x+534 pages. Vol. five and six xx+596 pages. 1960. Dover Publications, Inc., New York, N. Y. Price $15.00 for set.

THEORY OF PROBABILITY, by William Burnside. Paper. Pages xxx+106. 20.5 ×13.5 cm. 1960. Dover Publications, Inc. New York, N. Y. Price $1.00.

HOW TO TROUBLESHOOT TV SYNC CIRCUITS, by Ira Remer. Paper. 128 pages. 21.5×14 cm. Price $2.90. 1960. John F. Rider Publisher, Inc., New York, N. Y.

BASICS OF FRACTIONAL HORSEPOWER MOTORS AND REPAIR, by Gerald Schweitzer. 176 pages. Paper. 1960. John F. Rider Publisher, Inc., New York, N. Y. 23×15.5 cm. Price $3.90.

ASTRONOMY OF STELLAR ENERGY AND DECAY, by Martin Johnson, *Doctor of Science, Fellow of the Royal Astronomical Society and of the Institute of Physics,* Paper. 216 pages. 20.5×14 cm. 1960. Dover Publications Inc., New York*f* N. Y.

THE INTERNAL CONSTITUTION OF THE STARS, by Sir A. S. Eddington, *Associate Professor of Astronomy, Columbia University.* Paper. Pages xvi+407. 21×14 cm. 1960. Dover Publications, Inc., New York, N. Y. Price $2.25.

SYMBOLIC LOGIC, by Clarence Irving Lewis & Cooper Harold Langford. Paper. 518 pages. 20.5×13.5 cm. 1960. Dover Publications, Inc., New York, N. Y. Price $2.00.

THE PHYSICS OF TELEVISION, by Donald G. Fink and David M. Lutyens. Paper. 160 pages. 18×10.5 cm. 1960. Doubleday & Company, 575 Madison Avenue, New York, N. Y. Price 95¢ ($1.10 in Canada).

THE THEORY OF OPTICS, by Paul Drude. Paper. Pages xxi+546. 20.5×13.5 cm. 1960. Dover Publications, Inc., New York, N. Y. $2.45.

MATHEMATICS OF FINANCE, by Robert Cissell and Helen Cissell. Paper. Pages vi+86. 28×20.5 cm. 1960. Houghton Miflin Company, Boston. Price $1.80.

EXPLORING SCIENCE SERIES, Teachers' Edition. By Walter A. Thurber, *Professor of Science, Cortland State Teachers College, Cortland, New York*. All cloth. All 15.5×21.5 cm. Allyn and Bacon, Inc., Boston, Mass. 1960.
Book One—111+160 pages.
Book Two—107+176 pages.
Book Three—120+200 pages.

USING MATHEMATICS, by Kenneth B. Henderson and Robert E. Pingry. Cloth. Pages xvi+559. 14×21.5 cm. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. 1960. Price $4.16.

ALGEBRA, by Kenneth B. Henderson and Robert E. Pingry. Cloth. Pages xiv +434. 15×23 cm. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. 1960. Price $4.20.

INTERMEDIATE ALGEBRA FOR COLLEGES, by Rosenbach, Whitman, Meserve, Whitman. Pages ix+315+xxxi. 16.5×23 cm. Cloth. Ginn and Company, Statler Building, Boston 17, Massachusetts. Price $5.00.

THE WRIGHT BROTHERS, by Henry Thomas. Cloth. 126 pages. 13.5×20 cm. G. P. Putnam's Sons, 210 Madison Ave., New York, New York 1960. Price $2.50.

SCIENCE FOR BETTER LIVING SERIES, by Brandwein, Hollingworth, Beck, Burgess, and Strahler. All cloth. 1960. All 23.5×16 cm. Harcourt, Brace and Company, New York 17, N. Y. 1960.
YOU AND YOUR WORLD, 474 pages.
YOU AND YOUR RESOURCES, 536 pages.
YOU AND SCIENCE, 702 pages.

FIND A CAREER IN MEDICINE, by Robert S. Starrett. Cloth. 160 pages. 13.5×20 cm. G. P. Putnam's Sons, 210 Madison Ave., New York, N. Y. 1960. Price $2.75.

HOW TO USE YOUR TELESCOPE, edited by Edmund Scientific Co., 101 E. Gloucester Pike, Barrington, N. J. Paper. 21.5×28 cm. Price 60¢.

FUN WITH OPTICS, edited by Sam Brown. Paper. Edmund Scientific Co., 101 East Gloucester Pike, Barrington, N. J. 21.5×28 cm. Price 50¢.

TIME IN ASTRONOMY, edited by Edmund Scientific Co., 101 East Gloucester Pike, Barrington, N. J. Paper. 21.5×28 cm. Price 60¢.

MATHEMATICS REFRESHER, by Kurt Wolter. Cloth. 96 pages. 18.5×12 cm. Philosophical Library, Inc., 15 East 40 Street, New York 16, N. Y. 1960. Price $3.75.

THE RADIO AMATEUR'S HANDBOOK, by the Headquarters Staff of the American Radio Relay League. Paper. 24.5×16.5 cm. 728 pages. American Radio Relay League, Administrative Headquarters, West Hartford 7, Connecticut. 1960. Price $3.50.

CLASSICAL MATHEMATICS, by Joseph E. Hofmann, *Honorary Professor, University of Tubingen*. Cloth. 159 pages. 13.5×21 cm. Philosophical Library, Inc., 15 East 40 Street, New York 16, N. Y. 1960. Price $4.75.

NUCLEAR POWER PLANT, by E. Openshaw Taylor. Cloth. Pages vii+184. 1960. 13.5×22 cm. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $7.50.

ESSENTIALS OF GENERAL SPEECH, by A. Craig Baird, *Department of Speech and Dramatic Art, State University of Iowa* and Franklin H. Knower, *Department of Speech, Ohio State University*. Cloth. Pages x+242. 15×23 cm. 1960. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $3.95.

ELECTRICITY, by Arnold Mandelbaum. Cloth. 157 pages. 20.5×15 cm. 1960. G. P. Putnam's Sons, 210 Madison Ave., New York, N. Y. Price $2.95.

ESSENTIALS OF BUSINESS ARITHMETIC, by Edward M. Kanzer and William L. Schaaf. Cloth. Pages xiii+497. 23.5×16 cm. D. C. Heath and Company, 285 Columbus, Boston, Massachusetts. 1960. Price $3.80.

VECTOR ANALYSIS, by Manuel Schwartz, *University of Louisville*, Simon Green, *University of Windsor, Canada*, W. A. Rutledge, *University of Tulsa*. Cloth. Pages xii+556. 23.5×15 cm. Harper and Brothers, 49 East 33rd Street, New York 16, N. Y. 1960. Price $7.50.

ESSENTIALS OF COLLEGE CHEMISTRY, by Paul R. Frey, *Professor of Chemistry, Colorado State University*. Cloth. Pages xvii+520. 23×15 cm. 1960. Prentice-Hall, Inc., 70 Fifth Ave., New York 11, N. Y. Price $6.95.

CAREERS AND OPPORTUNITIES IN CHEMISTRY, by Philip Pollack. Cloth. Pages xii+147. 20.5×13.5 cm. 1960. E. P. Dutton & Co., Inc., 300 Fourth Avenue, New York, N. Y. Price $3.50.

THE WONDER OF LIGHT, by Hy Ruchlis. Cloth. 154 pages. 23.5×15 cm. 1960. Harper & Brothers, 49 E. 33rd Street, New York, N. Y. Price $2.95.

THE LOGIC OF MODERN PHYSICS, by P. W. Bridgman, *Higgins University Professor Emeritus in Harvard University*. Paper. Pages xiv+228. 21×14 cm. 1960. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $1.25.

ELECTRONIC COMPUTERS, by T. E. Ivall. Cloth. Pages viii+263. 21.5×14 cm. 1960. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $15.00.

FIND "MEADOWS" OF OCEAN GRASS ALONG PACIFIC CENTRAL AMERICA

Discovery along Pacific Central America of "meadows" of marine grasses and of reefs formed of calcareous seaweeds has been reported by the Beaudette Foundation for Biological Research.

The grass meadows were found on shallow sand and silt bottoms from central Panama to at least as far north as Cortino, Nicaragua. Believed to serve as grazing grounds for sea turtles, such beds had not previously been known to occur in the eastern Pacific.

Neither had reef-building coralline algae of the type associated with corals in atolls throughout the tropical Pacific been previously reported to occur along the Pacific Central American coast. But at Isla del Cano, Costa Rica, reefs were observed in which these binding and pavement-forming algae were prominent among the corals.

Although several species of massive algae were found that were capable of extensive reef formation, their limitations seemed to be due to relatively rapid solution that probably prevents accumulation of large calcareous formations.

Book Reviews

UNDERSTANDING CHEMISTRY, A Brilliant Survey of Man's Conquest of Matter, by Lawrence P. Lessing. Paper. Pages vi+192. 11×18 cm. 1959. The New American Library of World Literature, Inc., 501 Madison Avenue, New York 22, New York. Price $.50.

Here is a popular book on chemistry which can be read and understood by the layman. For a book of only 185 pages it covers a wide span of time. The first chapter is entitled, "The Beginnings of the World" and includes a most recent theory by Dr. Urey which endeavors to explain the origin of our earth and other bodies in space. Chapter two, is entitled "The Beginnings of Knowledge" and treats the history of early chemical knowledge beginning with Democritus and other ancient Greeks down through the period of alchemy and the works of A. L. Lavoisier, John Dalton, Kekule, Mendeleev, and on to the work of the Curies.

The remaining seven chapters deal with more modern chemical developments such as structure of the atom, metallurgy, synthetic chemistry, giant molecules, transistors, new drugs, harnessing of solar energy, and recent progress in the field of biochemistry.

I feel that this book belongs on the shelf of high school libraries in order that it may be available to the students of high school chemistry.

GERALD OSBORN
Western Michigan University
Kalamazoo, Michigan

FUNDAMENTALS OF ELECTRONICS, by F. H. Mitchell, *University of Alabama*. Cloth. Pages xi+260. 15×23 cm. 1959. Addison-Wesley Publishing Company, Inc., Reading, Massachusetts. Price $6.50.

Fundamentals of Electronics is a textbook written primarily for a one-semester introductory course for electronics majors. However, it would also be useful in courses for non-majors, since the mathematical treatment has been kept to a minimum. Some calculus has been used, but omission would not destroy the continuity.

In this new edition, several important changes and additions have been made. Among these are: expansion of the discussion of resonance, inclusion of a section on solving circuits by means of complex numbers, and expansion of the section on electron ballistics. Many new problems and examples have been included.

It is the opinion of the reviewer that this textbook is well-written and is adequate for the purpose for which it is intended. It is worthy of consideration by anyone interested in a textbook for the first electronics course offered after general college physics.

J. BRYCE LOCKWOOD
Highland Park Junior College
Highland Park, Mich.

TOPS AND GYROSCOPES, by R. W. Campbell. Cloth. 174 Pages. 14.5×22 cm. 1959. Thomas Y. Crowell Company, New York, New York.

Tops and Gyroscopes is a book written for the layman interested in a non-mathematical discussion of gyroscope principles. The book appears to be written so that a high school student, or beginning college student, would find it interesting and informative.

The author has included the historical development of the top and gyroscope as well as presented practical applications and elementary theory. Many demonstrations and experiments have been suggested that would be useful in the classroom. The diagrams are well done and presented where they are needed most.

It is the opinion of this reviewer that this book would be an excellent addition to the high school or college library.

J. BRYCE LOCKWOOD

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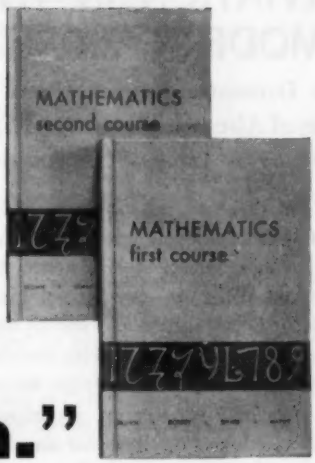

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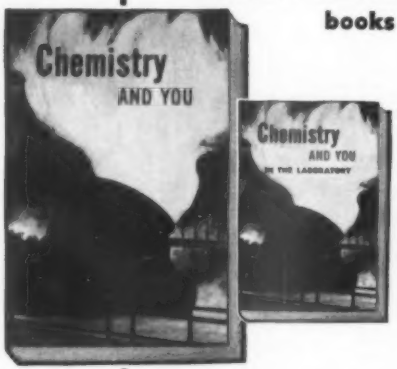

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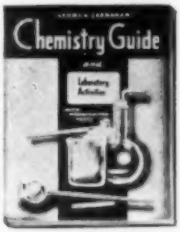

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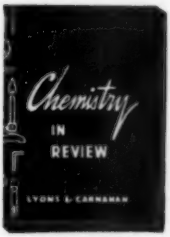

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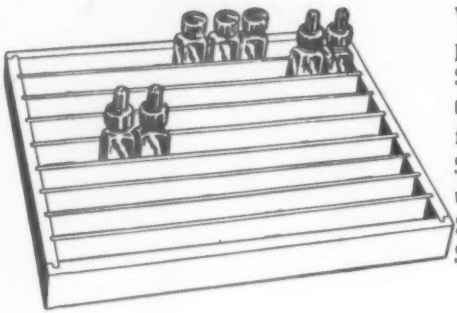

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